THE PRODUCTION ENGINEER

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

SEPTEMBER 1960

THE PRODUCTION ENGINEER

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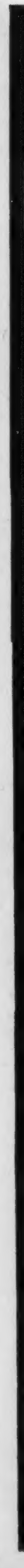

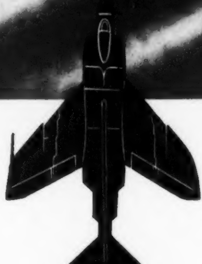

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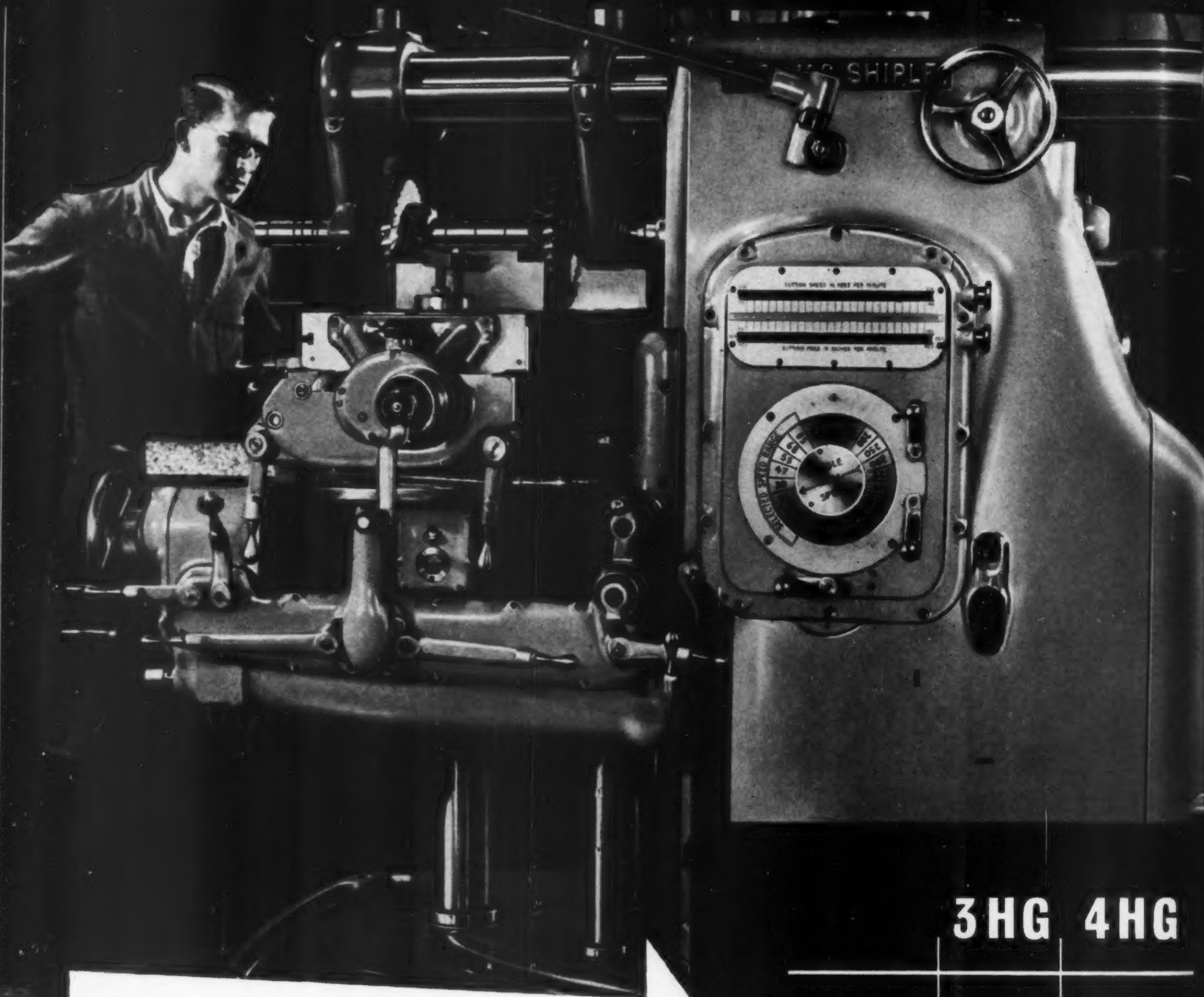

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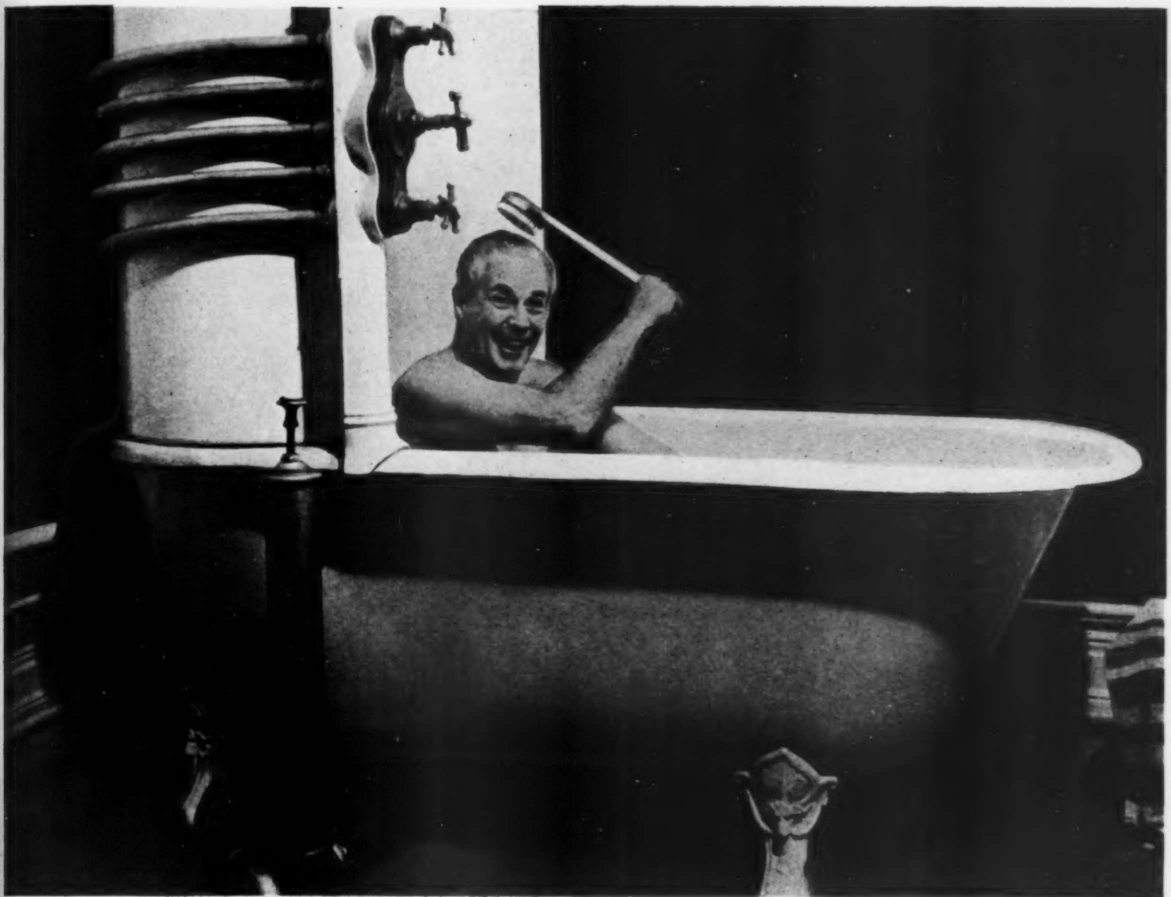

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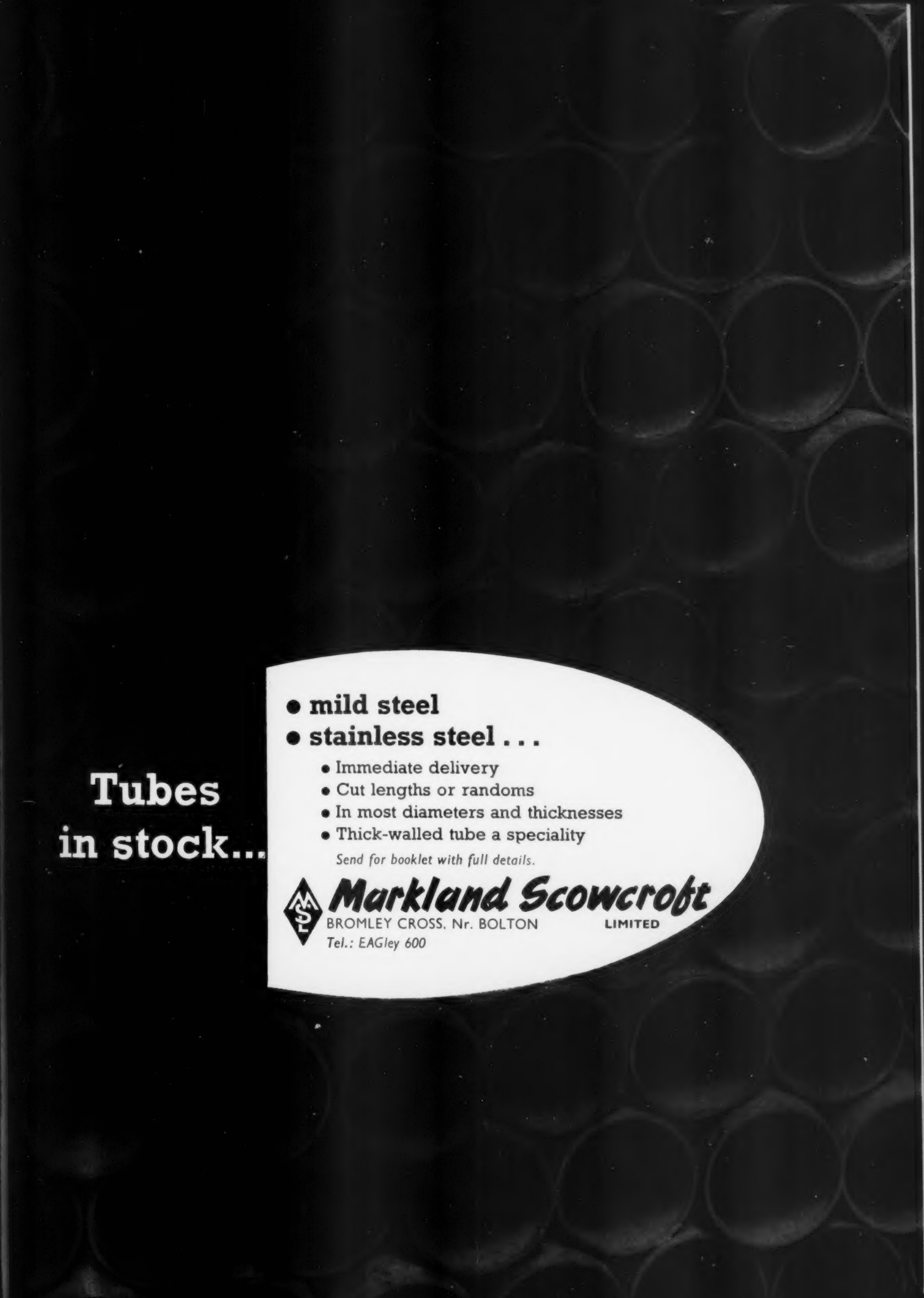
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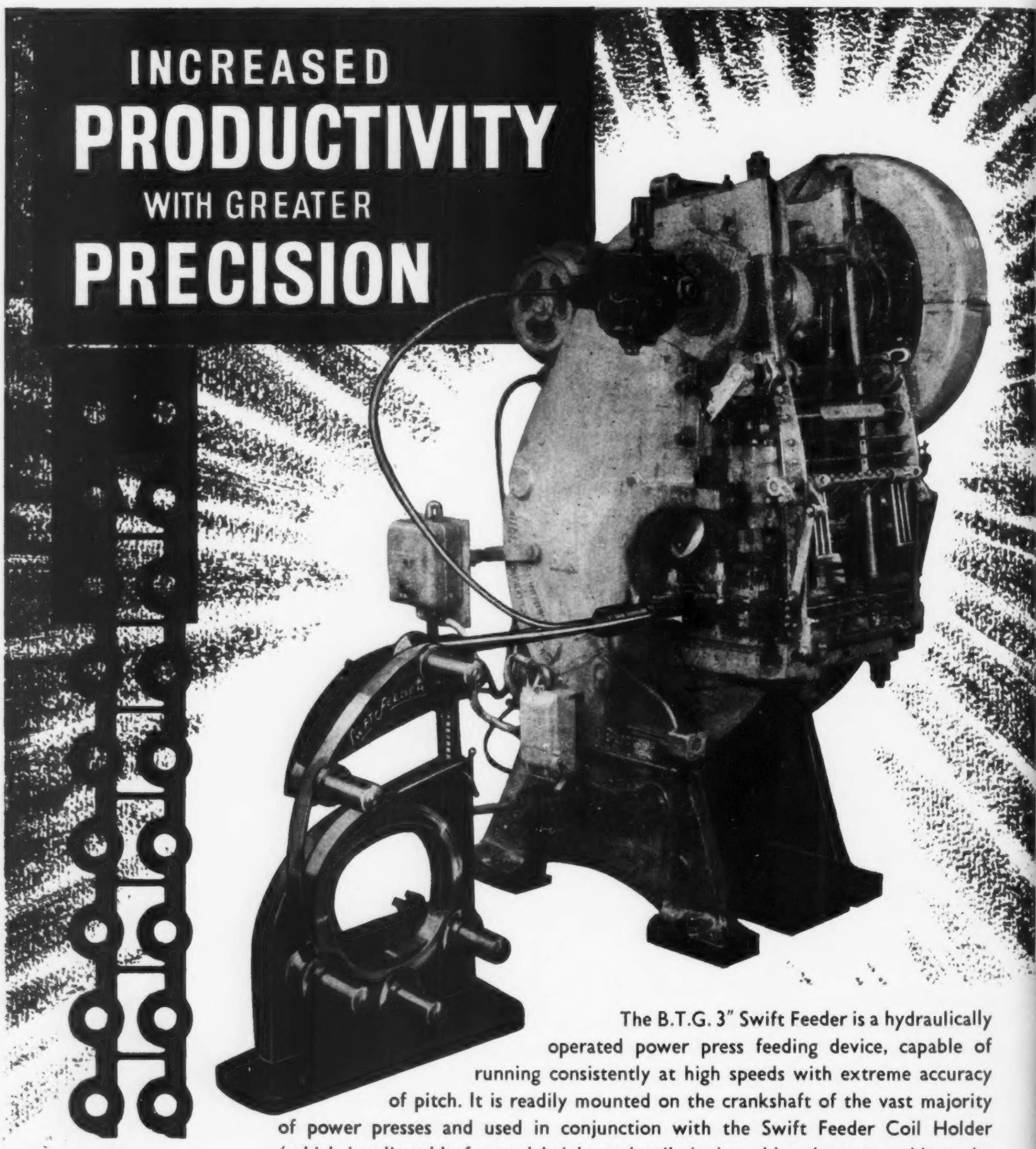

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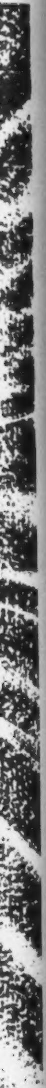

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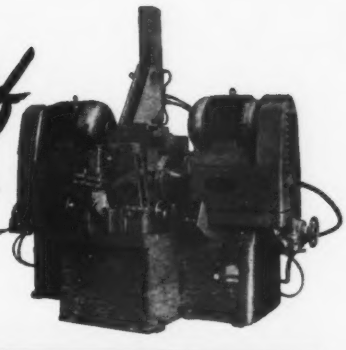

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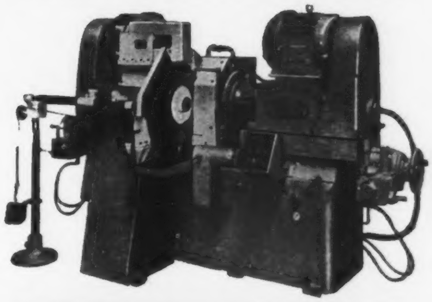

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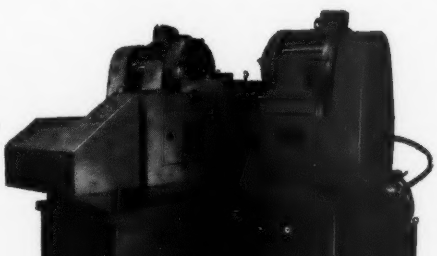

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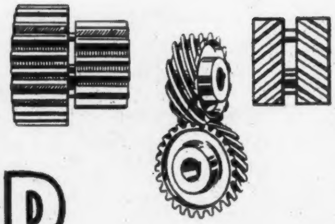

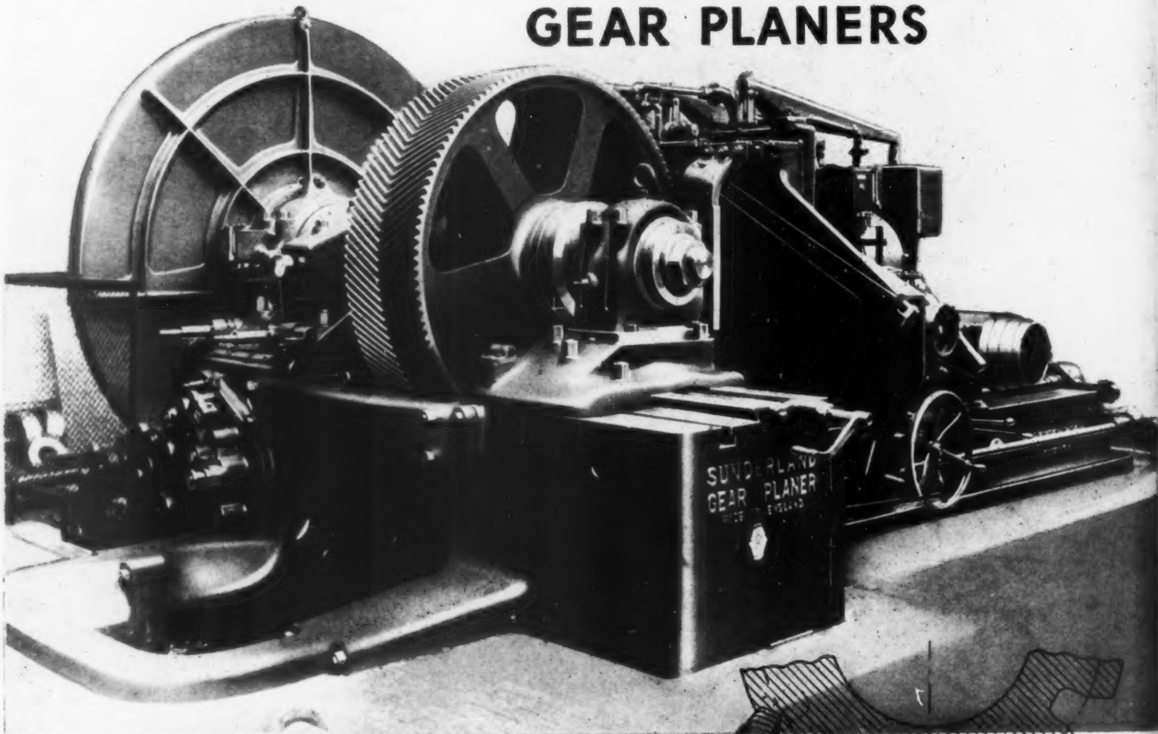

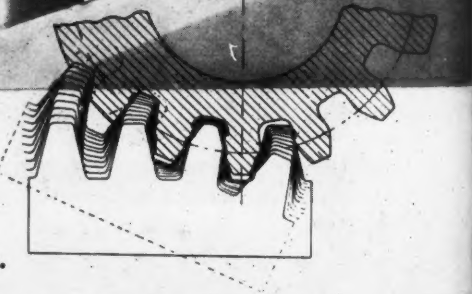

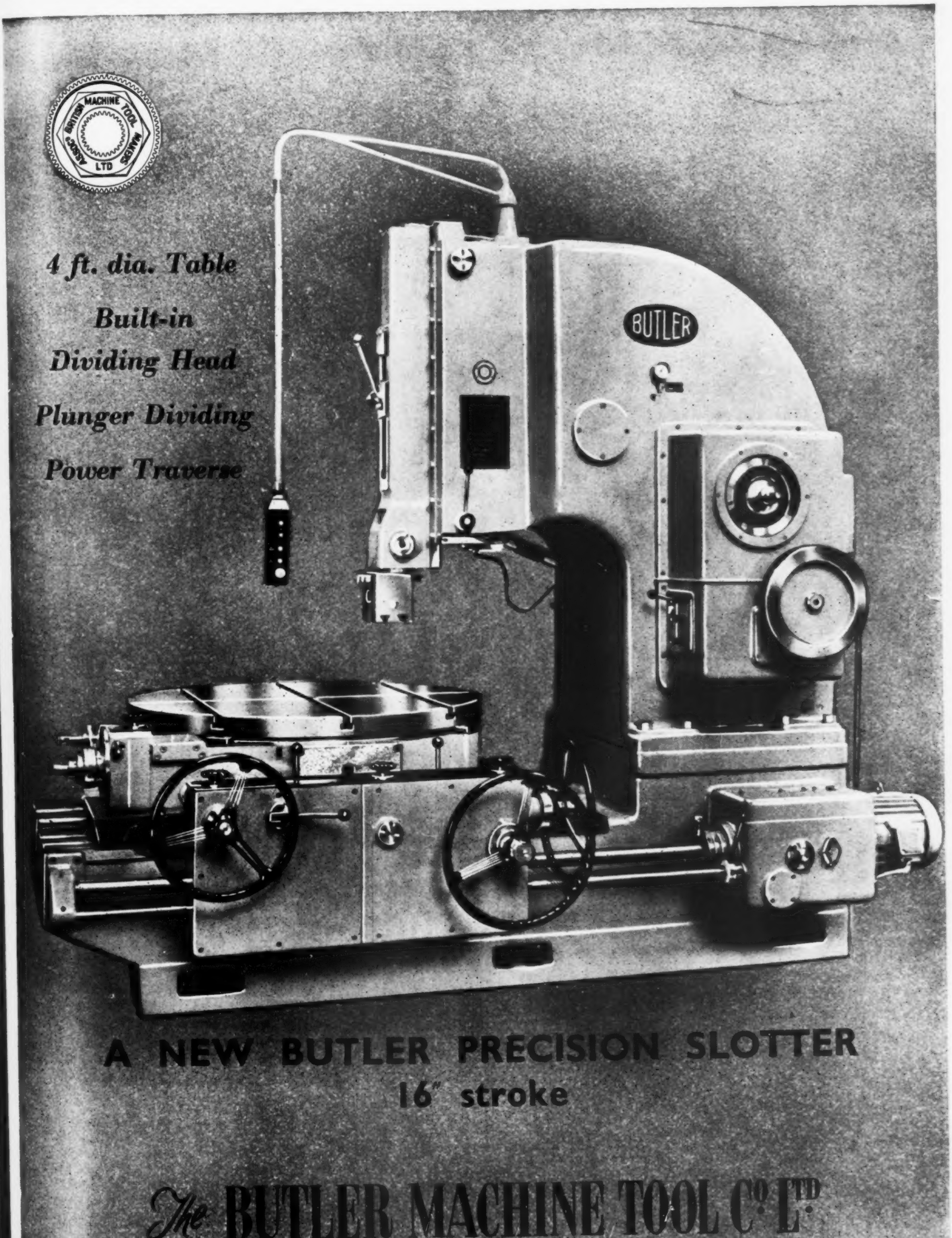
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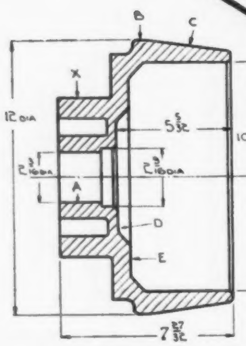

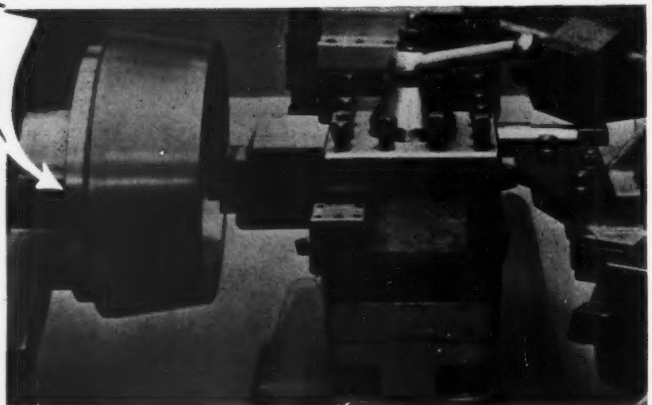

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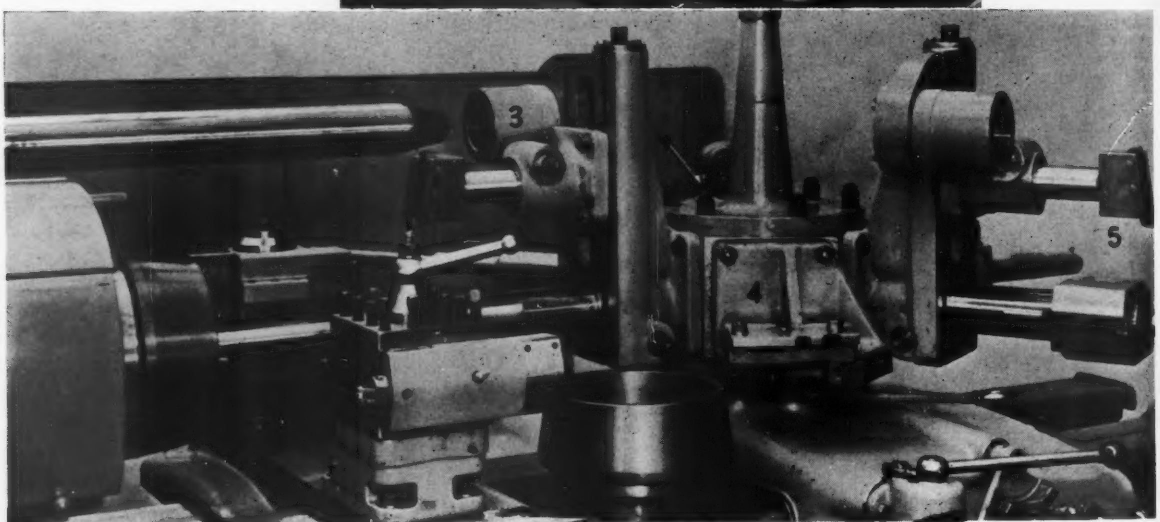

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Chuck on X (using Loading Attachment)	1	—	—	—	Hand
2. Rough Bore A & $2\frac{9}{16}$" dia. and Chamfer	2	—	375	260	64
3. Face (2 Cuts)	—	Front 1	93	278	64
4. Rough Bore 10" dia. Rough Knee Turn B and Rough Taper Turn C	— 3	— Rear	75	240	44
5. Contour Face D & E (Rough & Finish)	4	Front 3	93/125	242/325	64
6. Finish Bore 10" Finish Knee Turn B and Finish Taper Turn C and Chamfer 10" dia.	— 5	— Rear	125	390	64
7. Chamfer Outside Dias.	—	Front 2	125	390	Hand
8. Finish Microbore $2\frac{3}{16}$" dia.	6	—	580	333	88
9. Remove (using Attachment)	1	—	—	—	Hand

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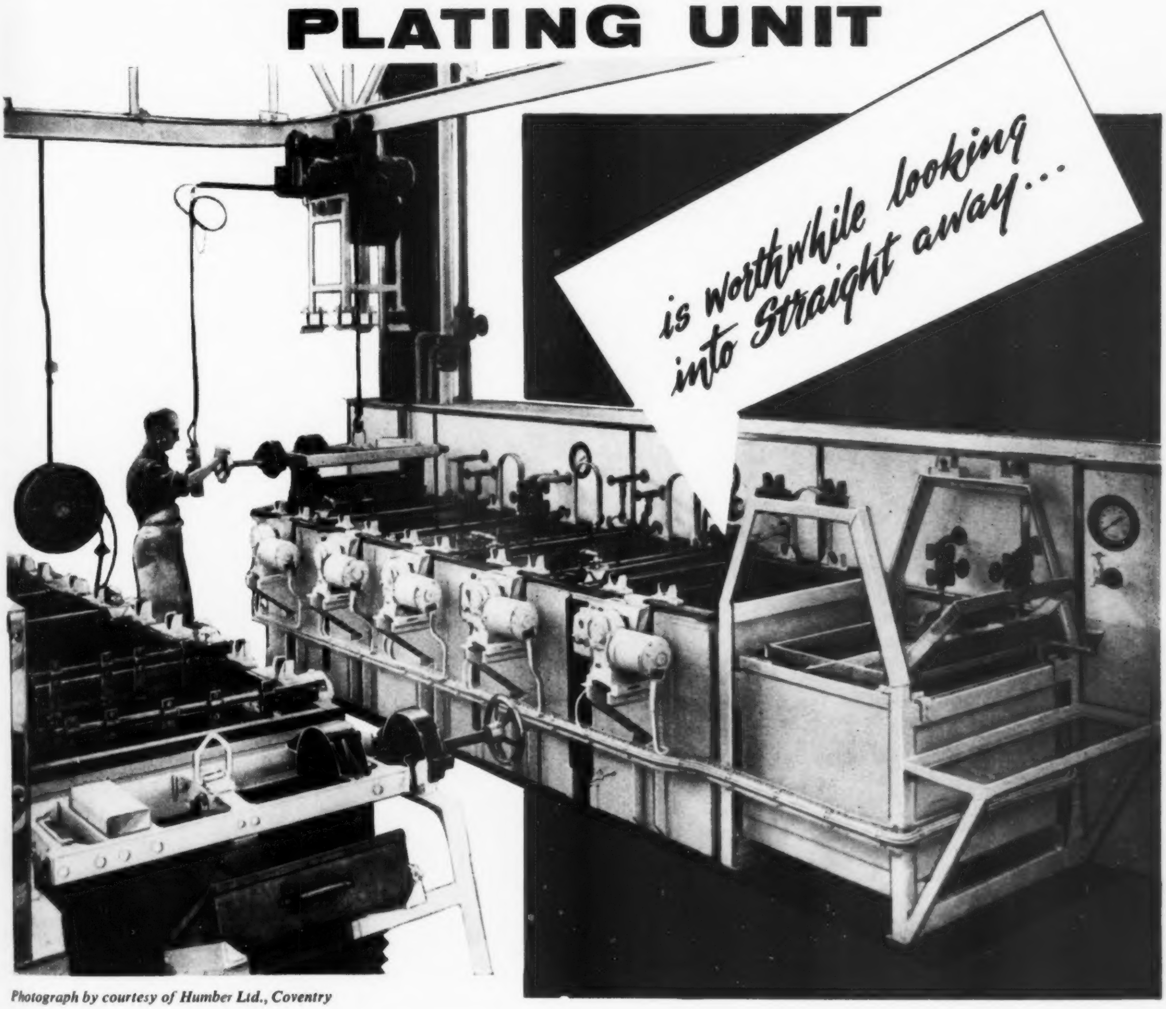

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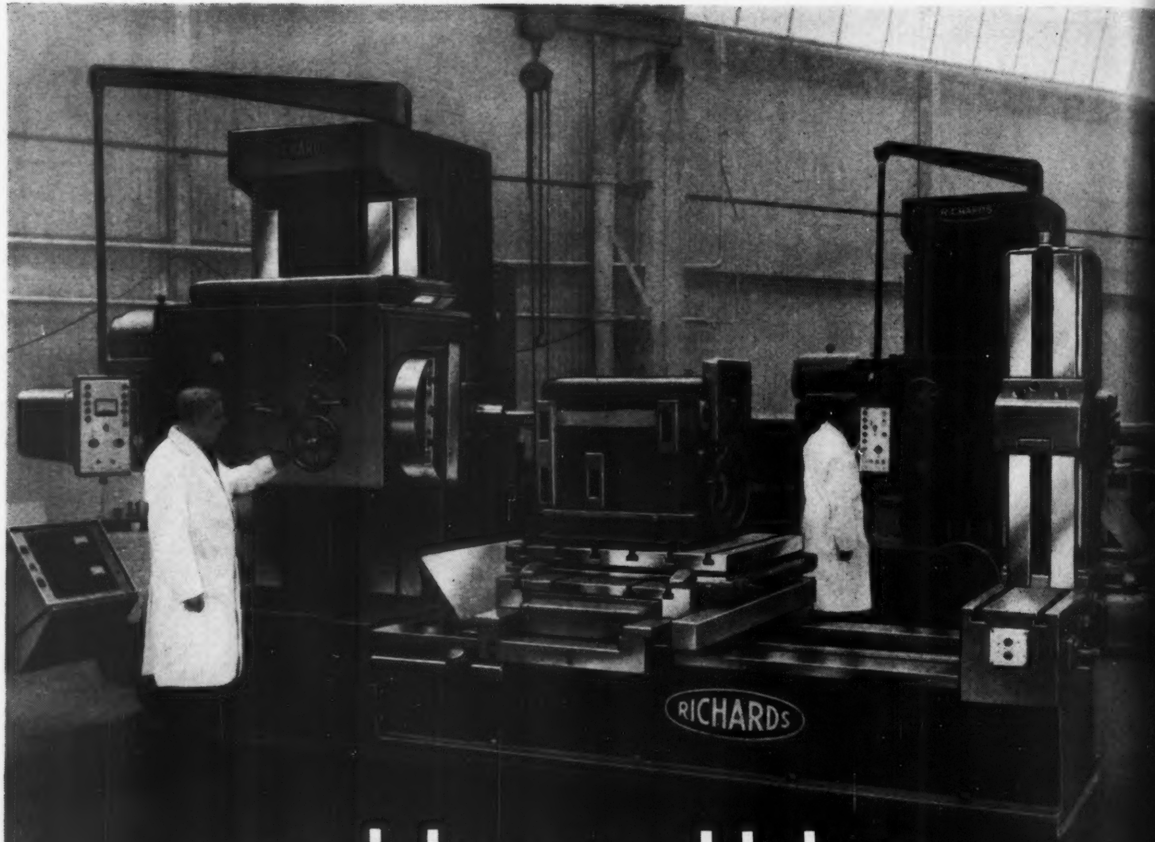
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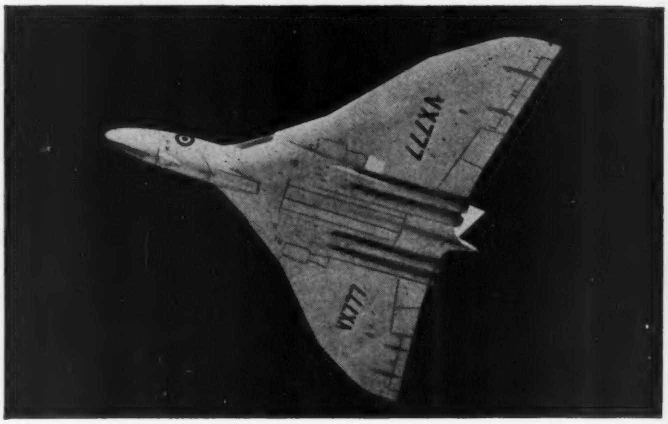

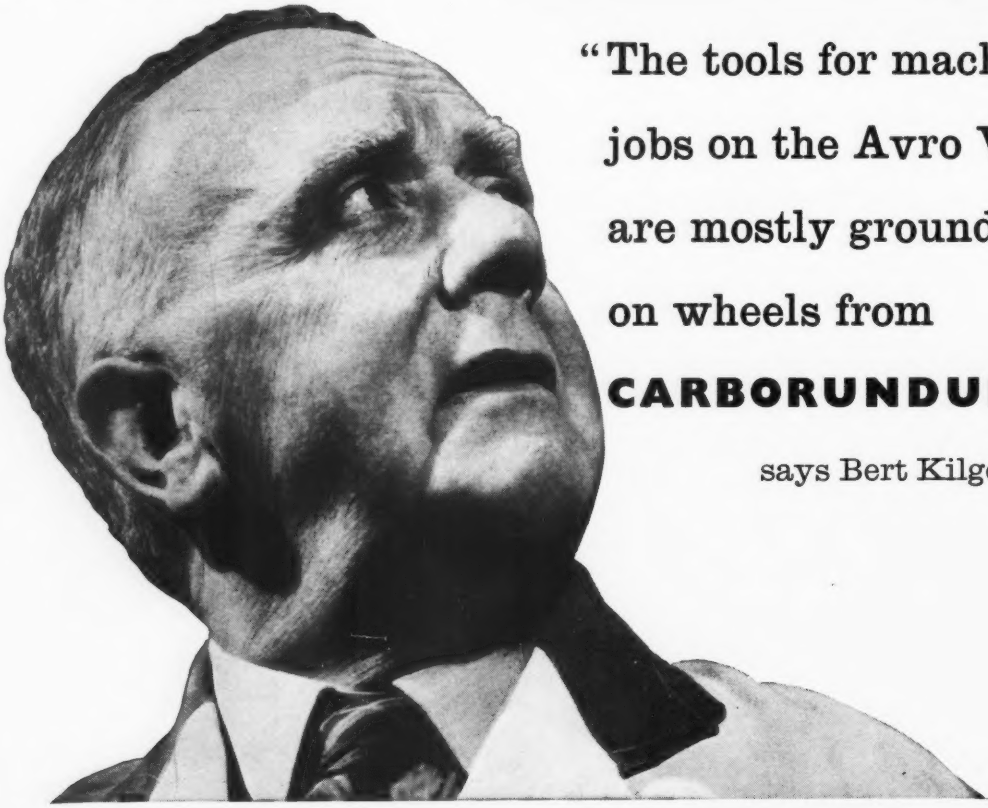

"The tools for machining jobs on the Avro Vulcan are mostly ground on wheels from **CARBORUNDUM**"

says Bert Kilgour

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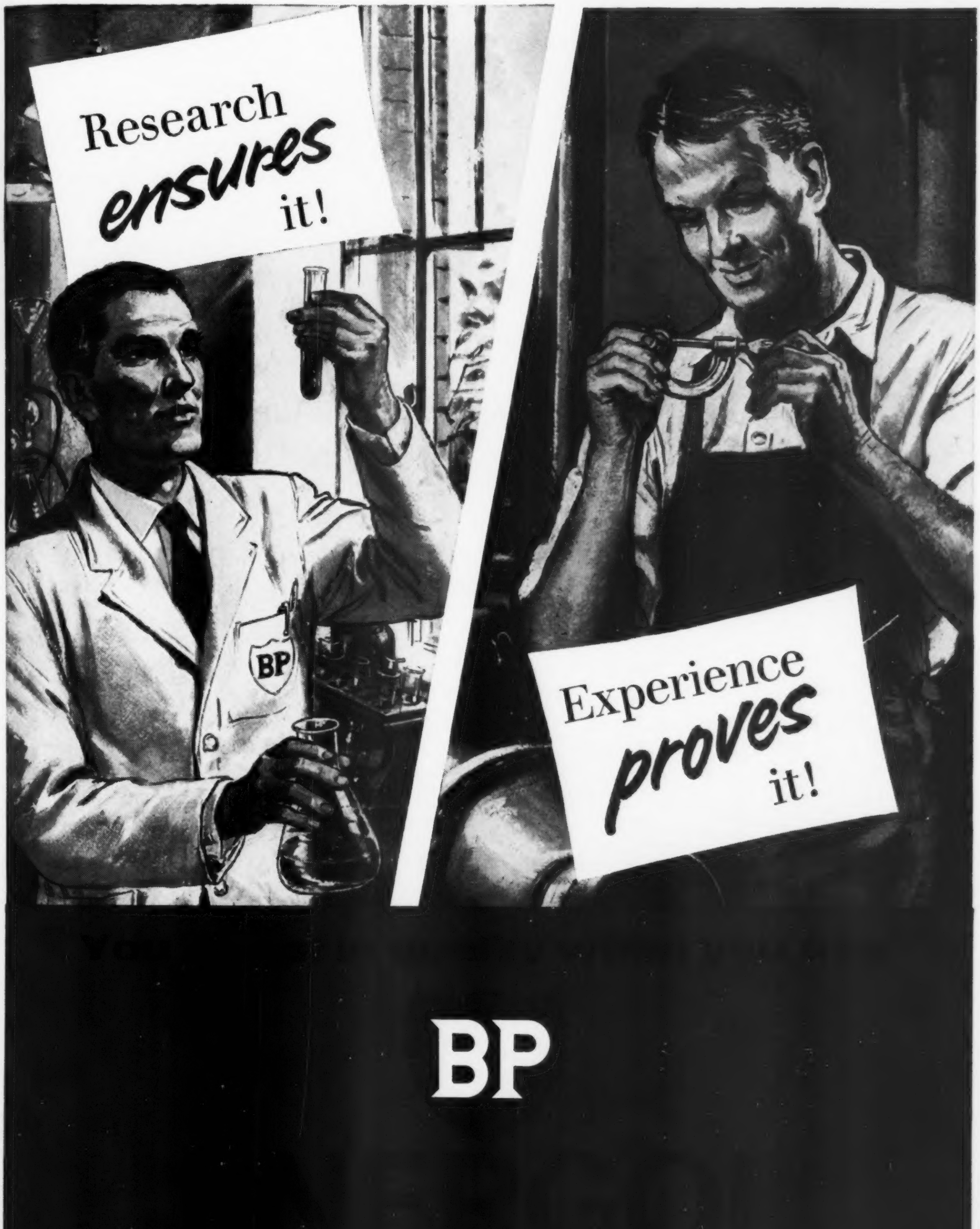
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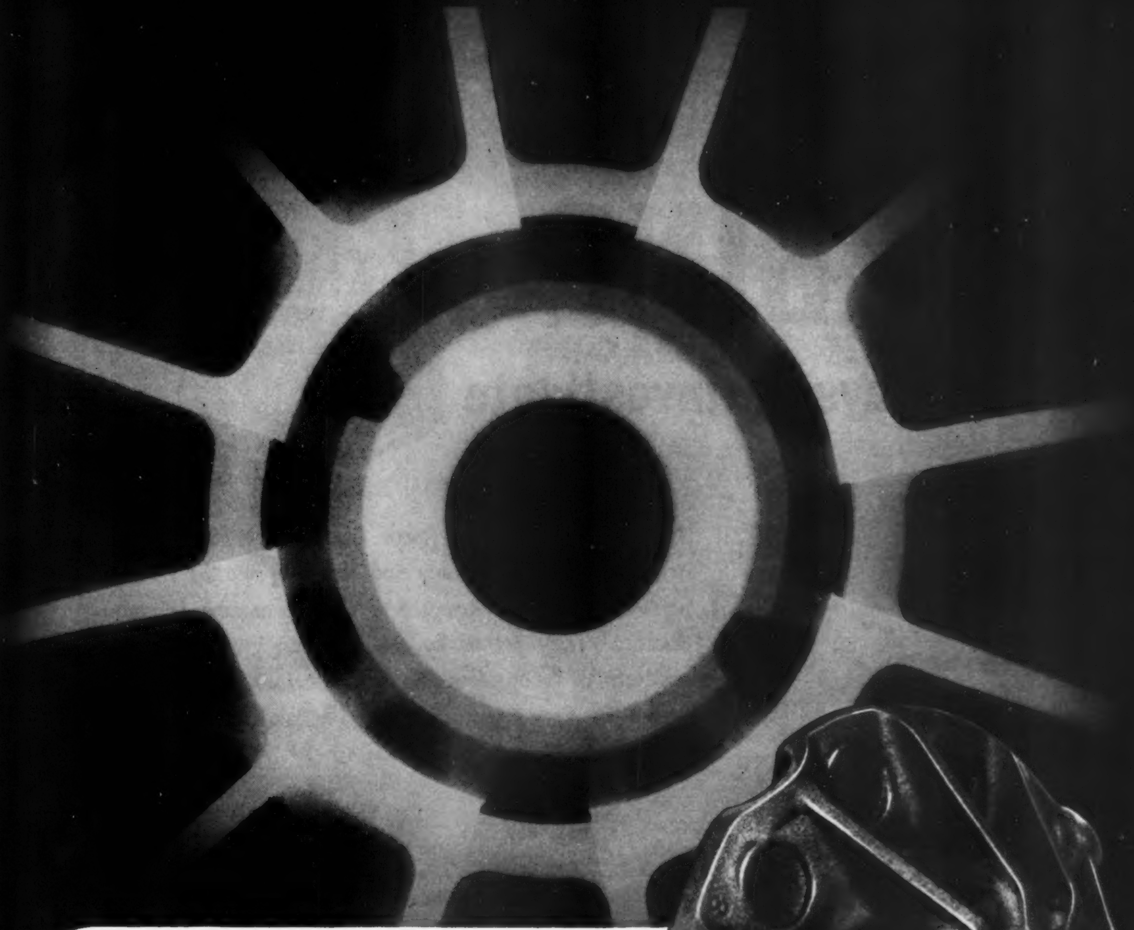

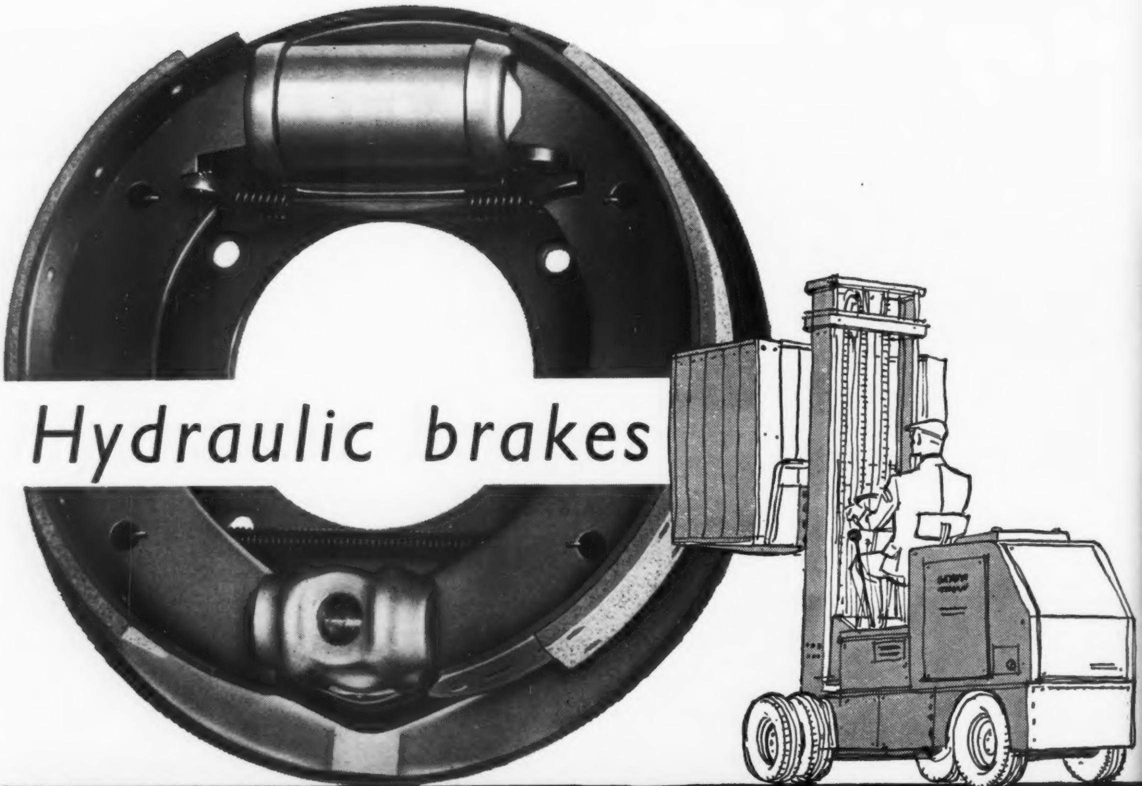

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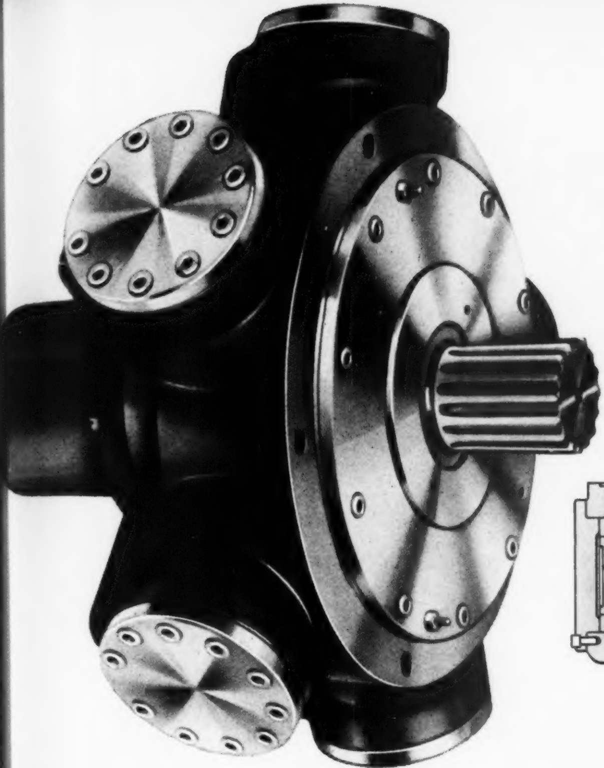

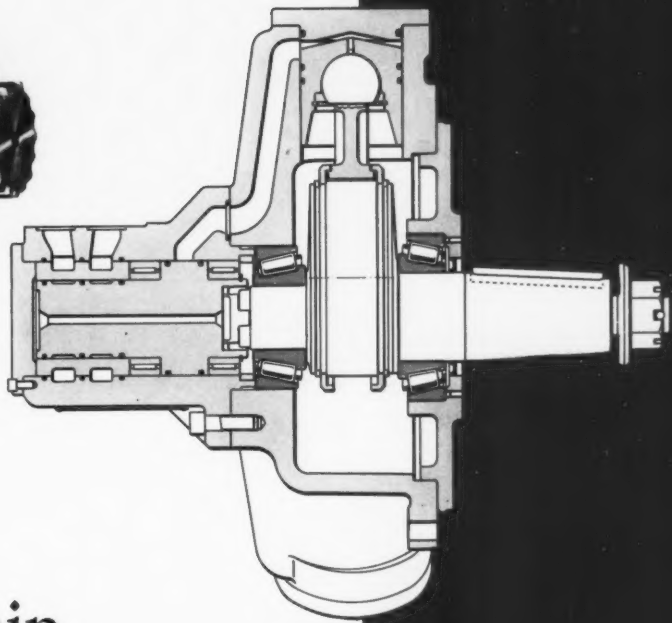

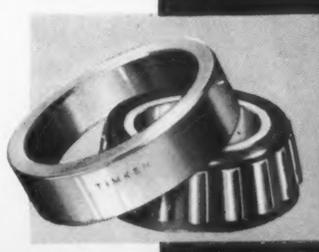
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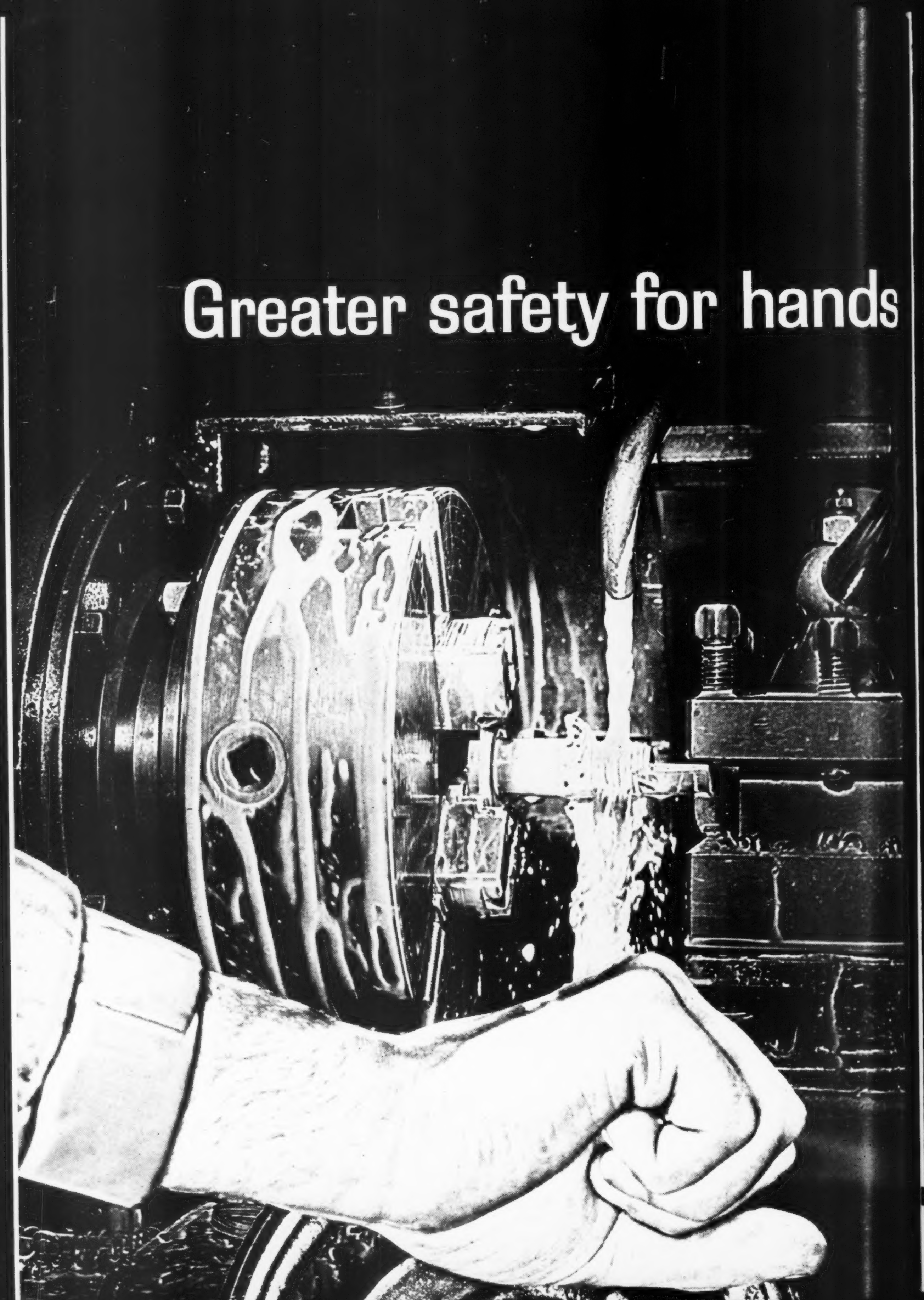
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The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 No. 9 SEPTEMBER, 1960

10 CHESTERFIELD STREET

MAYFAIR . LONDON . W.1

FROM THE PRESIDENT

Dear Fellow Member,

At the last Council Meeting, in July, I gave notice of a motion for a debate on Institution policy to take place at the next Council Meeting to be held on 27th October, 1960, for the following reasons :

Firstly, because it was obvious from most of the replies I received to my letter to all members (following the refusal of our petition for a Royal Charter) that the membership was straining at the leash to demonstrate, with even greater emphasis than ever before, that production engineering had a most significant part to play in world affairs, and that The Institution of Production Engineers was competent to lead and to guide this effort.

Secondly, because it was obvious from long discussions with the Secretary on his return from his overseas tour that some new thinking would have to take place regarding overseas membership.

It therefore seemed to me to be a good thing to do to prepare (with the assistance of the Institution staff) a memorandum on these and related subjects and to use it as a basis of seeking advice from my fellow Principal Officers and others. This exercise has now been completed — mostly by meetings but in some cases, unavoidably, by correspondence. The advice received has been extremely valuable to me and has helped me to modify some of my first thoughts and to reach my own conclusions, which have now been embodied in a memorandum which has been circulated to all Members of Council as an *aide memoire* for the discussions — and, it is hoped, the decisions — which will take place on 27th October, 1960.

You will, of course, be informed in due course of what transpires.

Yours sincerely,

ENGINEERING RESEARCH AND ITS STATUS IN AUSTRALIA

by L. P. COOMBES, D.F.C., F.C.G.I., F.R.Ae.S., A.M.I.E.(Aust.), F.I.A.S.(U.S.A.)

This Paper was presented to The Institution of Production Engineers on 10th November, 1959, in the University of Sydney, New South Wales, as the fourth James N. Kirby Paper.

Mr. Coombes is Chief Superintendent of the Aeronautical Research Laboratories of the Department of Supply in Australia.

The meeting, for which the arrangements were made by the Sydney Section, was attended by over 500 members and guests.

THE theme of my address is engineering research, and I shall divide it into two parts. In the first I shall try to explain what engineering research is. I shall then deal with the status of engineering research in Australia and how it may perhaps grow and become more effective.

I am, of course, attempting to show the importance of research to industry, and as a general introduction I should like to quote from a book published recently by a leading Australian Company : " Research is now an accepted tool of management. In a competitive economy no organisation can stand still and the need for research stems from the basic necessity for the organisation to grow and change. Nationally, research is an important factor in achieving greater productivity on which living standards depend."

what is engineering research ?

Scientific research is work which is directed towards :

(a) the discovery and enunciation of unifying principles in relation to the behaviour of the system or phenomena being studied;

(b) the development of a language to describe this behaviour which simplifies the description and aids the logical development of new ideas.

Without these, any step forward in technology must be made cautiously and checked carefully at every stage. It was thus the early engineering inventors proceeded. Common sense, intuition and luck were the tools of the successful ones; there is little record of the others.

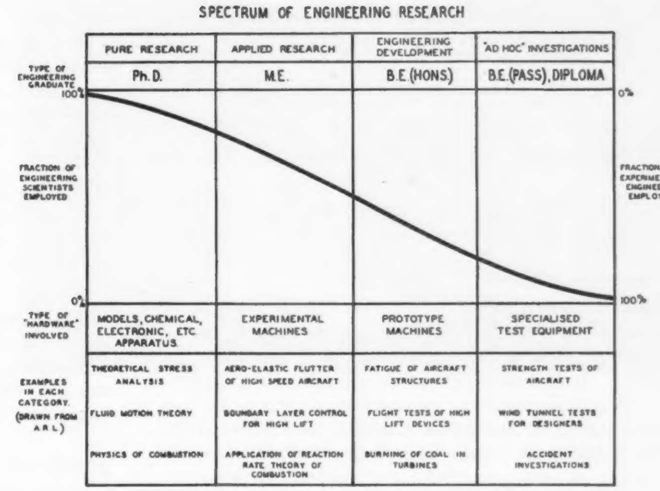


Fig. 1. Spectrum of engineering research.

The big advances were made by men with sufficient wisdom to collate similar phenomena and put forward possible unifying principles, which they were able to describe in a language (mainly mathematics) which aided logical thought. The names of Faraday, Kelvin, Heaviside, Routh, Froude, Michell, Ampere, Carnot and many others come to mind. One may recall that all the foundations of modern computers were laid by Charles Babbage's mathematical researches in Cambridge more than 100 years ago. The full realisation of his ideas had to await such modern techniques as electronics and the mass production of small accurate parts.

While basic scientific work is the foundation of modern engineering, the role of the engineer is often that of active link between basic research and technology; he uses the fruit of scientific progress and turns it to the practical service of man. The application of research is his recognised field.

This gives engineering research a wide scope. Sir Harold Roxbee-Cox, in a lecture to The Institution of Mechanical Engineers, used the highly descriptive term " spectrum of research ". Similarly, The Institution of Engineers, in its survey of engineering research in Australia, included all levels of research from fundamental to *ad hoc* investigations. I shall accept this wide definition and, to make it clearer, a diagram has been prepared which sets out the kind of work and the type of professional engineer appropriate for it. (Fig. 1.) At one end of the spectrum are fundamental studies in such subjects as applied mechanics or electrical theory, and from there we pass through the development of elemental equipment involving new principles and finally come to specialised test work. The men vary correspondingly. At the research end of the spectrum is the academic type—the man who after graduation has spent three or more years in research at a university and obtained a Ph.D.; he naturally gravitates to fundamental or basic research. One passes through engineers with Master's and Bachelor's degrees to those with a Technical College Diploma. As the diagram shows, each kind of work requires a varying percentage of each type of research worker and this will be reflected in the laboratory organisation.

The aim of engineering research is technological progress; to produce a transport vehicle of higher performance, a power plant of greater efficiency, or a structure of lower weight. This aim should surely appeal to production engineers, since there must be a relation between the demand for a product and its excellence.

methods of engineering research

In common with all forms of scientific research, research engineers follow the four steps of the so-called scientific method :-

1. study of the problem, preferably in its normal environment;
2. formulation of a hypothesis regarding the causes of the difficulties encountered;
3. tests of the hypothesis;
4. application of the results as a solution to the problem.

Naturally, the details of these steps vary with the problem and the steps may merge into one another. For example, study of the problem in its environment may be so difficult that a more convenient reproduction of it in controllable circumstances would be necessary. Again, it may be impossible to formulate a hypothesis regarding causes unless separate effects of the variables, i.e., the study is extended to variations of the original problem.

In engineering research the problem being studied often involves large or costly items or difficult circumstances of operation, so that the study itself and any variations in the problem would consume large amounts of time or money. Under these circumstances reproduction of the problem in a simpler or

more convenient form is necessary. Thus, there have grown up three techniques which are used separately or in combination :-

(a) *Mathematical Study*. This involves a representation of the problem in symbolic form—i.e., by mathematical equations.

(b) *Experiments with models* usually to a smaller scale.

(c) *Simulation by some form of analogue* such as an electrical network.

Mathematical Studies

The mathematical study is by far the cheapest since it involves very little equipment, perhaps only pencil and paper with, at the most, access to a computing machine. It is, however, extremely difficult to reproduce practical problems completely in mathematical terms, and great mathematical skill and physical insight (which are rarely found in combination) are necessary in order to make the simplifying assumptions which render the problem amenable to calculation. Modern computers help, but are not by any means the answer to the difficulty.

Experiments with Models

Scale models for various purposes have been used from the beginning of civilisation, but reproducing the full-sized machine or piece of equipment by an accurate scale model is not enough. Dynamical similarity between the conditions of operation of full scale and model must also be achieved. It is not possible to satisfy all the conditions simultaneously and hence the most important are selected and the effects of the others estimated.

The first really scientific use of models for engineering purposes was for determining the form of ship's hulls. William Froude, in 1871, showed how the various dynamical factors could be reproduced or allowed for in ship model tests. The most important condition to satisfy is that waves created by the motion of the model vessel are exactly similar (to scale) to those produced by the actual ship. The wave resistance can then be actually predicted but the frictional resistance of the wetted surface, especially in the presence of rivets, joints, barnacles, and other roughnesses, is not subject to the same laws.

Froude showed how the wave-making and frictional resistances could be separated and scaled up. His Paper on the work is a classic and this technique of ship tank testing has remained unaltered to this day.

In Australia, as in other countries, models are widely used in the design of aeroplanes, hydraulic dams and spillways, harbours or river silting, shore erosion, etc. Model research is an insurance against extremely costly and dangerous mistakes.

Simulation.

Simulation is a comparatively modern technique. An early use of it was in the design of acoustic systems when it was found that such systems could be more conveniently studied by analogous electrical circuits. Such simulators or analogues are very extensively used today. For example, the aerodynamic behaviour of an aeroplane can be reproduced by an electrical network and elaborate ground trainers have been evolved which allow pilots to be trained to fly new types of aeroplanes. Thus, many hours of flying time of extremely costly aeroplanes can be saved and the risk of a crash eliminated.

Simulation is particularly useful in the evolution of complicated engineering devices like guided missiles. Each test involves the destruction of one missile, the cost of which may well run into thousands and even tens of thousands of pounds. A complete development programme involves testing missile behaviour under

Fig. 2. A typical towing tank for testing ship models.

(Courtesy of National Physical Laboratory, Teddington.)

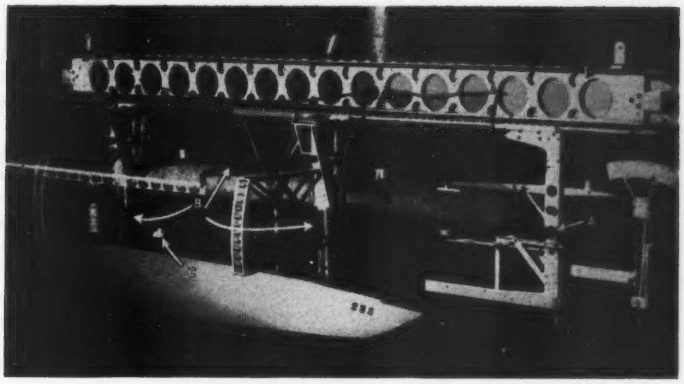


Fig. 3. Model of a yacht hull on force recording balance.

a great variety of inter-related conditions, with possible repetition due to failures.

Cost considerations limit the number of actual firing tests to less than 100. The procedure then is to build up a representation of the missile and its control system, using a suitable analogue computing machine. The behaviour of the missile under given conditions of firing is then compared with that of the analogue. When the analogue has been developed to a stage when it represents sufficiently accurately the measured behaviour of the actual missile under test, many hundreds of variations and combinations of the test conditions can be studied on the simulator at small cost and in a short time. The actual missile firings can thus be limited to those necessary to make overall and critical checks of the laboratory data obtained. Simulators are used in other fields. Thus, Cornell University in U.S.A. has built a car-driving simulator for research on human behaviour when confronted by dangerous traffic situations. This is another example of non-destructive testing!

To sum up, the forms of engineering research described have one object: to save money by reducing costly, time-consuming or dangerous full scale experiments; in other words, to offer an alternative to learning the hard way.

examples of engineering research

One of the engineering industries which has benefited greatly from research is the aircraft industry. Indeed, it is probably true to say that none of its advances could have been achieved without research. The Wright Brothers constructed their own wind tunnel and did essential research on wing profiles before building their aeroplanes, and even earlier, Laurence Hargreaves, in Australia, made many notable contributions to the science of flight.

Every subsequent advance has been achieved on the basis of extensive research. Much of this has been painstaking, systematic work for the express purpose of giving the designer the basic information which enables him to work out the best compromise among the many conflicting elements which make up a new design in this complex engineering field. However, this rather pedestrian approach would never have

Fig. 4. 1/40 scale model of the Cotter No. 2 dam under test in the Research Laboratories of the Snowy Mountains Authority.

achieved the spectacular advances which have been made. In aeronautics there has been a great body of forward-looking investigation, the broad purpose of which is to provide answers to the questions which the designers will be asking five or ten years hence. This kind of research requires men of inspiration and fundamental outlook, and is comparable with the academic research being done in University laboratories. The only difference is that the aeronautical research will have specified objectives even though these be broad and distant, whereas the University worker is not trammelled; he can " follow the gleam ".

The difficulties in aeroplane design are great because weight and safety are paramount considerations. The whole economy of a long range transport aeroplane lies in the 10% or less of useful load it carries. Any change in fuel consumption, structure weight, or engine power results in a much greater proportional change in payload, which would certainly have a major effect on the operator's profits. The external form, too, is very important. It is evolved by elaborate wind tunnel investigations, and in the manufacture it must be reproduced to close tolerances; the wing profiles of a supersonic aeroplane are accurate to a very few thousandths of an inch. The conditions of operation cause great fluctuations of loading on the structure due to atmospheric turbulence, and to the great variations of pressure and temperature involved in ascending from ground conditions to the stratosphere. These fluctuations would cause failure by fatigue unless the structure and the materials of which it is made are specifically designed to combat this. In supersonic aeroplanes these problems are intensified.

Guided missiles are but a step from supersonic aeroplanes. Here the emphasis shifts from aerodynamics, the structure and propulsion unit to automatic control and guidance. The removal of the man is a major step; the loss of the pilot's skill is not important because over the years, automatic pilots and powered controls have been perfected. Nevertheless, the human brain still compensates for the shortcomings of the machine, even if the operator is virtually only a monitor. When the man is removed from the vehicle to the ground, the degree of automation involved increases enormously and in the case of a satellite launch or its military equivalent, the inter-continental ballistic missile, the accuracy of the controlling elements becomes fantastic. The research equipment, quite apart from the quality of the scientists, is in the " super " category.

commercial applications

You may ask where this is leading; what effect has all this high-faluting stuff on commercial engineering production? The answer is that inevitably all these advanced techniques ultimately filter down into ordinary commercial use.

Thus guided weapons involve the highest level of automation, with computing machines controlling the programme of operations. At a recent engineering exhibition I saw an Australian-designed grader in which the angle of the blade was held fixed in relation to the horizontal, whatever gyrations the grader itself might be constrained to perform by the

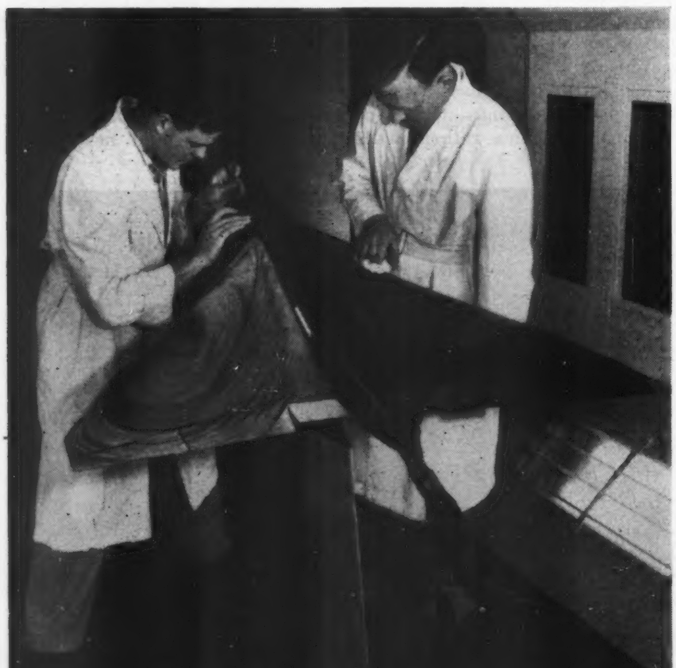


Fig. 5. Aeroplane model in a wind tunnel, showing surface air flow.

undulations of the road. The control mechanism, in a crude form, was exactly that used to stabilise an aeroplane or a guided missile in space. Again, programmed controls are now being fitted to machine tools so that the sequence of operations and the movements of the cutting tool relative to the work are ordered by an electronic computing device. This has greater advantages than the mere replacing of a human operator. It also replaces the elaborate tooling required for accurate production; moreover, changes in the product merely require that a new control tape be calculated for the electronic controller.

Surface transport has benefited considerably from aeronautical techniques. Two recent examples are shown in Figs. 9 and 10. Fig. 9 shows the Lockheed Company's contribution to the problem of suburban transport. It is the old idea of monorail cars elevated over streets, but by using advanced aeronautical construction and braking techniques and automatic controls, they hope to achieve average speeds approaching 60 m.p.h. A short length of this type of railway has been built in Seattle. Fig. 10 shows a completely new conception, the Hovercraft which enables a vehicle to ride on a cushion of air over land or water. If successful, it may revolutionise marine transport.

Australia's contributions

Australia has also made contributions to engineering and industrial research. One of the earliest is found in the annals of the Colonial Sugar Refinery Company. As long ago as 1880, Mr. E. W. Knox, later Sir Edward, became dissatisfied with the efficiency of the sugar mills. He engaged two overseas chemists and they established scientific investigation and control with the most beneficial results. In this record can be distinguished the four stages :-

(i) dissatisfaction with the technical efficiency of the operation, i.e., recognising the problem;
(ii) enlisting men with special technical skill;
(iii) research by these men into the problem;
(iv) taking effective steps to implement their findings into actual working practice.

Again, most of the knowledge of the conditions which govern the transmission of radio waves around the earth and through the ionosphere has come from the researches undertaken in Australia under the auspices of the Radio Research Board. Such knowledge is of vital importance to the telecommunications industry, and in war, to the Services. Without it, the Overseas Telecommunications Commission, the Post Office, the broadcasting authorities and others would not have been able to maintain the radio communications which are so much a part of today's life.

Many other examples can be quoted. The Michell thrust bearing and theory of lubrication; McKay's harvesting machine; Radio Distance Measuring Equipment on Australian airlines; automatic trimming device for bulk cargo handling; the list could be extended substantially.

Operational Research

The engineering researches so far described are

Fig. 6. Avro type 707A in flight showing surface air flow. This aeroplane is a two-fifth scale model of the Vulcan bomber.

almost entirely of a physical nature and involve precise quantitative data. In recent years new branches of engineering research have arisen which take into account both human characteristics and the variability of non-human factors, for example, the weather. This broad field is called "Operational Research" and came into its own during World War II.

One such branch is called Human Engineering. It has grown out of the well-known science of time and motion study and deals with the matching of the man to the machine. It is most relevant when either the speed of operation of the machine or the stress of circumstances surrounding its operation tend to outgrow the capacity of the human operator. Typical examples are the piloting of a large high speed aeroplane, and the operation of various forms of military equipment under battle conditions.

A local example of Human Engineering investigation was that conducted by the Aeronautical Research Laboratories. The landing of aeroplanes is a phase of their operation which is the greatest single cause of accidents. The research workers concerned, by elaborate questionnaires to large numbers of civil and military pilots and by flying with aircrews, determined the judgments which the pilot is called upon to make, and how many sources of information are available to him. The conclusion was that there is no redundant information available to the pilot and, in fact, in adverse weather insufficient cues are available.

This led to the evolution of two new forms of landing aid. One is an array of lights which at night or in poor visibility daylight conditions enable the pilot to determine his precise relation to the optimum glide path. The other is an airborne instrument which supplies an artificial horizon and glide path information when approaching in mist or cloud. This is displayed not by an instrument on the dashboard, but projected at infinity through the windscreen. Thus, a pilot can give full attention to looking for the ground when he breaks through cloud and yet

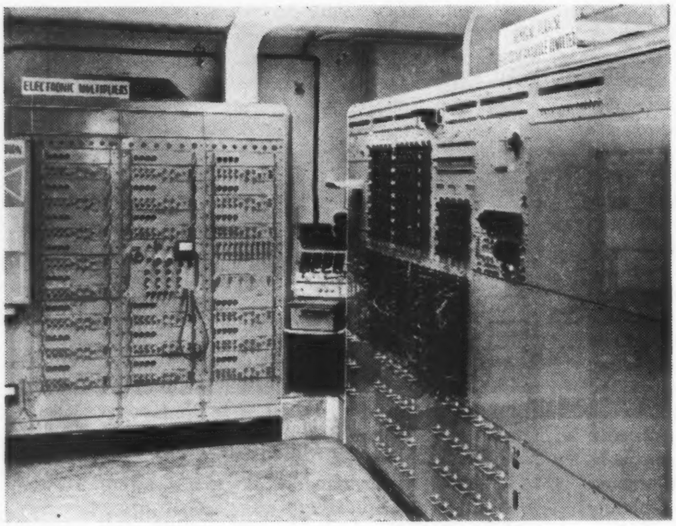


Fig. 7. General purpose analogue computer used for missile research.

see all the relevant information needed to guide him on the correct glide path. I am happy to say that the ground based aid, known as Precision Visual Glide Path, is being installed at two overseas and many Australian aerodromes and is being tested by several countries which are interested.

In the Aeronautical Research Laboratories we have developed another form of Operational Research which employs the Theory of Games. This technique is applicable to any situation in which there is competition between two opposing sides and we have, on behalf of the Australian Services, investigated the best methods of defending certain vital areas. The object of the exercises was to choose the best type of defensive equipment from those types available, and to optimise the strategy of their employment. To this end, a statistically planned series of games is played representing various attacks and defences. In these, human operators make the necessary decisions, and to ensure realism, the games are played in real time and under conditions imposing a certain degree of stress. To simulate practical conditions, each of the various factors, e.g., the range at which an enemy aircraft is detected by radar, is not assigned a definite value but chosen at random from a range of values with a probability distribution about the most likely.

After the results of the series of games are analysed the significance of the variables emerges, and it is possible to differentiate between the effectiveness of rival defence systems. This analysis can also be used to determine the optimum strategy under given conditions and thus a strategic doctrine can be evolved.

Operational Research techniques are being applied, particularly in America, to a variety of industrial situations, for example, transport systems. One could imagine a use for the technique in studying the relation between production and marketing—a sort of customer *versus* salesman game.

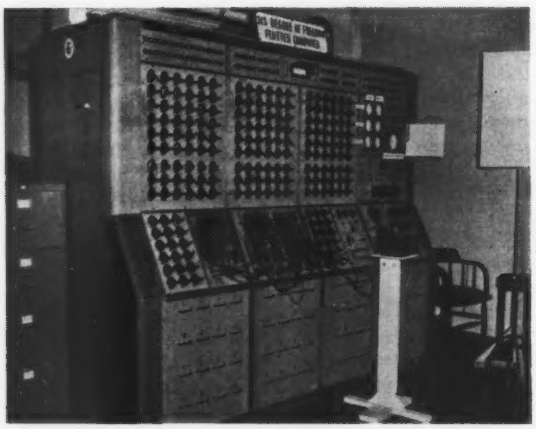


Fig. 8. Special purpose analogue computer used for aero-elastic investigations.

the status of engineering research in Australia

Australia today has many notable engineering achievements to her credit and a wide range of engineering products, many of them quite complex, are manufactured here. Nevertheless, the general state of development is far from satisfactory and I propose now to make a brief survey. To commence, I shall quote one of the conclusions of a top level management conference held recently in Australia:

> "We live in a scientific and technological age in which rapid changes and advances are taking place and progressively gathering momentum. Nowhere in the free world is industrial progress more rapid than in Australia. At the same time the expanding population can no longer be

supported on the export of primary products alone and we must gain a share of overseas markets for our manufactured goods. Until we can compete on equal terms with other countries in a truly competitive environment in both primary and secondary fields of enterprise we shall not become a great nation. To do so we must advance our industries with research. We have lived on borrowed fruits in the past and must learn to stand on our own feet in this regard."

The foregoing conclusion is in accord with the generally accepted fact that research and a high standard of living are bound together. Moreover, a country aspiring to a high living standard must be prepared to carry out research over a wide field and not merely in narrow directions where material returns appear to be certain and quick.

Yet, if the figures for expenditure on research are examined, it is clearly seen how Australia is lagging behind other countries. The following figures refer to the years 1955 - 56.

	U.S.A.	*U.K.*	*Canada*	*Aust.*
Government Research and Development as % of Total Government Expenditure	3.8	4.5	2.5	1.5
National Research and Development as % of Gross National Production	2.3	2.0	1.0	0.4
Industrial Research and Development as % of Output	1.9	0.8	0.5	0.3
Professional Research and Development Personnel in Iudustry as % Total Industrial Employment	0.9	0.26	—	0.1

Australia is expending only a small fraction — between $\frac{1}{3}$ and $\frac{1}{6}$ — of the research and development effort being put forward by the U.S.A. and Great Britain. It is also well behind Canada, a country comparable in size and development with our own; in fact, many engineering industries are so far from being research-minded that they do not even employ professionally trained engineers or scientists. This has been revealed by a survey which was made by the Institution of Engineers in 1955.

This survey showed that the Government research laboratories each employed, on an average, nearly 30 professionally qualified staff. The Universities and technical colleges each had an average of about 20, while the 20 best engineering firms in Australia employed an average of six professional staff. The remaining large number of firms employed less than two, many of them having no professional staff at all.

This reluctance to employ professional engineers has its effect on the efficiency of the engineering industry in Australia. My Laboratory is a member of the Engineering Group Committee which brings together two research establishments of the Department of Supply and three research Divisions of C.S.I.R.O., all of which to some degree undertake research for the engineering industry. In these Laboratories a most impressive range of engineering sciences is available and efforts to publicise the work are made by "Open Days", information services, and the like. Nevertheless, only a small number of industrial firms avail themselves of the facilities. Of the enquiries received, some are on a high technical level; others show such a lamentable ignorance of first principles that the firms concerned could have no professionally qualified staff.

One common weakness in industry is failure to recognise that problems exist. This is evident when questionnaires are circulated on the incidence of such widespread difficulties as fatigue of metals and components. Too often the answer, if supplied by a non-technical management, is that no problem exists.

Another frequent deficiency is to undertake manufacture under licence of quite complex engineering products, and to introduce local modifications without having technical personnel competent to undertake such tasks. Incorrect processing of materials, particularly in heat treatment, forging and foundry practice, is common, and so is the wrong choice of material for products. This is often the result of ignorance of standard specifications and their use. Even companies of quite high standing tolerate rejection rates in production without setting up laboratory facilities to investigate and remedy them.

growth of research in Australia

It is clear that there is need for considerable growth in research in the engineering industries of Australia, though it is understandable that industry in Australia is not, as yet, interested in research in a fundamental way. It will initially be mainly interested in improving processes and methods in order to produce a given product in the cheapest manner consistent with good quality. The fact that it has been possible to do without supporting research by obtaining the required "know-how" from overseas has reacted on the engineering industries which have only comparatively recently introduced laboratory control of production.

However, we should keep this matter in perspective by remembering that organised applied research did not start in England or America until just before the First World War (it was a little earlier in the chemical field in Germany). In production engineering, industry did not move from empiricism to scientific method in America till 1940 and in England the Production Engineering Research Association was not established till 1948.

The era of technical dependence on overseas countries is passing and one can expect to see the growth of research following the pattern of :-

(i) establishment of laboratory control, e.g., checking materials, processes, etc.;

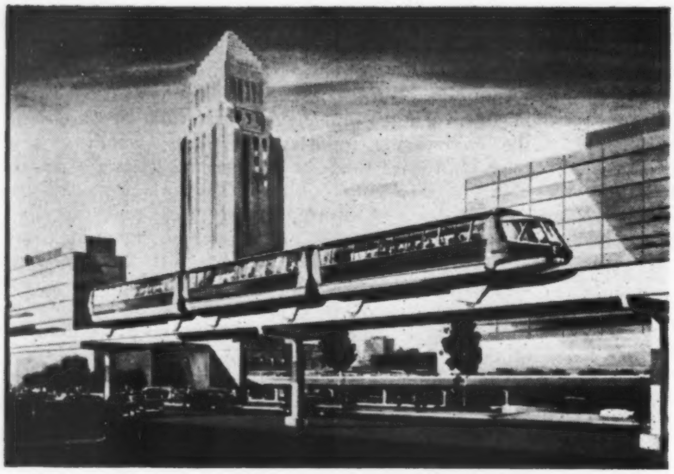


Fig. 9. Monorail street transport system proposed by The Lockheed Aircraft Company.

(ii) extension of applied research in Government instrumentalities and the universities, and setting up of research laboratories and research associations in private industry;

(iii) extension of basic research in Government and university laboratories and the sponsorship of some basic research projects by industry.

What does appear to be the important step is the extension from laboratory control of processes to applied research, as this marks the beginning of freedom from dependence on overseas manufacturers for technical information. Few firms will be able to establish their own research laboratories, but the smaller ones can group themselves into research associations and maintain one or two research men to ensure the intelligent assimilation of ideas.

Once applied research becomes part of the production scene it will not be long before the need for basic research in Government and university laboratories, if not in industrial laboratories, will manifest itself.

How does an activity of this kind start in a country which has up to now depended on overseas knowledge? Particularly, how can a small undertaking afford to set up research facilities? The answer is to form a research association among a group of companies in the same industry. This practice is widely followed in Britain where research associations are assisted financially by the Government through D.S.I.R. In Australia the movement has begun in a small way and six research associations have been formed so far. The Government subsidises these associations through C.S.I.R.O. in a manner similar to the U.K., but I regret to say that none of the six is in any branch of engineering manufacture.

The formation of a research association and the possible availability of specialised help from Government research establishments is only part of the picture.

A firm must itself have some staff — perhaps only one man — to enable it to take advantage of the information which would be forthcoming and, more important, to recognise that problems exist which need scientific attention. Too often is it a matter of pride not to recognise any shortcomings in one's product or deficiencies in the knowledge and experience of the staff.

To recapitulate, we should aim at three integrated spheres of research :-

(i) the firm's own research teams which are generally geared to definite short term objectives;

(ii) co-operative research associations which work on problems common to a whole industry and not specific to an individual firm. Thus, we have the Production Engineering Research Association of Great Britain, the object of which is to assist productivity by researches which lead to improvements in design and quality of production equipment and to the provision of technical data essential for the efficient use of such equipment.

(iii) University and Government research laboratories where long-term and fundamental researches are undertaken which are beyond the resources of individual firms, perhaps even of research associations. Such researches are vital for future progress. Moreover, the staff have specialised knowledge in particular directions and equipment of a character not readily available elsewhere.

As stated already, a prime necessity is for the firms to have staff who can take advantage of the assistance available in the second and third categories. The duties of such staff are to recognise the problems

in the firm's production and design activities, and to sort them into :-

(a) those that are specific to the firm itself. If the firm has no research department of its own it can employ an industrial laboratory, university or technical college, on a confidential basis if necessary;

(b) those that are common to the whole industry and appropriate to the research association;

(c) those that need basic information and should be referred to a University or Government research laboratory.

It is important that the staff in the firms should be encouraged to make contact with University staffs and Government scientists, as these contacts will help to clarify problems and reveal sources of information and potential facilities for investigation.

value of research

A great deal has been said about the lack of research in the engineering industries of Australia and how it should be remedied. The question may well be asked — " Does expenditure on research bring commensurate returns? " The answer is readily given in the primary industries by many brilliant examples of C.S.I.R.O. research : introduction of the cactoblastus beetle to combat prickly pear; myxomatosis and the rabbit; trace elements for soil deficiency; use of Australian hardwoods for paper making; to instance a few. In engineering, the answer is not so clear-cut. Research pays the greatest dividends in those engineering fields which are advancing quickly, like aeronautics and electronics. However, even in heavy mechanical engineering, which tends to spend least on this activity, research can pay handsomely. I have already referred to the research work by Froude on ships. This engineering research has paid incalculable dividends and it is probably true to say that it was one of the factors which gave British shipyards such a lead for 50 years. In my early days as an engineer, I served my apprenticeship in C. A. Parsons and Company, the famous turbine builders. At that time, Sir Charles Parsons directed the technical activities of the firm and he had maintained a vigorous research laboratory which he supervised personally. The firm in consequence pioneered not only the steam turbine but many other engineering inventions, and was in the forefront of technical development. Parsons himself died a near-millionaire, a most exceptional achievement for a professional engineer.

An argument which may be advanced for buying " know-how " which other countries have acquired by research and development is the small size of the market. In terms of domestic population, the U.S. market for a given product, say an automatic washing machine, is 17 times that in Australia, whereas the cost to design and perfect such a machine might be the same in either country. There is clearly a great incentive to buy a licence for the American machine, even if a comparatively high percentage fee must be paid.

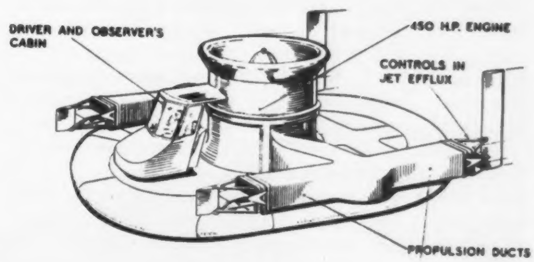
There are other factors to be considered. Research in the larger countries tends to be extravagantly manned and we have had examples in the defence field where a complex engineering product has been developed in Australia superior to either the British or American equivalent, and at a fraction of the cost. This is not an indication of superior ability — merely the result of better planning by having to produce results on a shoe-string budget. Thus, I feel that Australian industry should get a worthwhile result for a reasonable outlay on research and development. In any case, there may be no option in the matter when Australia starts to export manufactured goods in a big way. Overseas firms will not make " know-how " available when we begin to compete in the same markets.

There are considerable benefits in developing one's own products. The licencee of an overseas company is always a year or two out of date. Further, the full " know-how " may not be made available and Australian manufacturers often encounter considerable problems in putting overseas processes into local production. Two examples come to mind. One was the production of bearings, which failed alarmingly in service. In another case, when local forgings were used instead of importing supplies from overseas, the machining time was doubled. Yet the products were apparently identical.

By developing one's own products, they will be as up-to-date as our skill can make them — perhaps even in advance of overseas models. Furthermore, all the background knowledge will be available to overcome production difficulties or shortcomings which arise in service.

the utilisation of Universities and Government research laboratories by industry

I think it will be clear to anyone who examines the scope and cost of engineering research that it is beyond the resources of any one company to conduct all its own research. Even in the United States, where some of the big companies have extremely large and



S.R. N1 HOVERCRAFT

Fig. 10. Experimental Hovercraft built for the National Research and Development Corporation by Saunders-Roe Ltd.

Fig. 11. Operational research game to determine efficiency of a proposed defence system.

well-equipped research laboratories of their own, they depend very largely upon the researches conducted in University and Government laboratories for the more basic knowledge which they apply.

In Australia, very few industrial firms have research laboratories at all, and the scope of the ones which exist are very limited by overseas standards. Any application of research in Australia must depend almost entirely on the basic knowledge acquired in Government or University laboratories here and overseas. I would therefore like to discuss the organisation of research in Australia as it differs somewhat from that in other countries.

It has been stated by an eminent authority in Great Britain that, broadly speaking, all fundamental or basic research should be done in the Universities, and Government establishments should be limited to applied and *ad hoc* research. While it is true that the freer and untrammelled atmosphere of a University laboratory is more conducive to fundamental thinking, there are objections to such compartmentalisation. Moreover, in Australia the Universities are starved for money and we find few great University research centres such as the Cavendish Laboratory at Cambridge, and the almost equally active centres at London, Oxford, Bristol, Birmingham, Manchester and other Universities. As a result, the Government laboratories, particularly C.S.I.R.O., but to a lesser extent also the Atomic Energy Commission and the Research and Development Branch of the Department of Supply, are conducting fundamental research in addition to the applied and *ad hoc* research appropriate to their functions. In addition, both the equipment and the knowledge to solve industrial problems of a great variety are more likely to be found in Australia in a Government laboratory than in a University. This is unfortunate, since by their charters many Government laboratories, particularly the defence laboratories, are set up for particular purposes and only a small part of their efforts can be diverted to the needs of industry. Nevertheless, the resources of the Government laboratories are very large, and properly channelled, even a small proportion of the effort might make a great deal of difference to industry.

The basic policies in regard to aid to industry should be noted. C.S.I.R.O. by its very charter was set up for this purpose. Nevertheless, so many technical problems assail industry in an isolated country like Australia that the C.S.I.R.O. laboratories could easily be swamped under a flood of *ad hoc* enquiries and requests for investigation. Since the resources are limited the policy of the Executive Body must clearly be :-

(i) to have staff knowledgeable in the particular fields which they cover. This knowledge is not merely an encyclopaedic coverage of existing knowledge — this is the function of an information service. The need is for a dynamic approach whereby the staff is doing original research on the fringes of knowledge and is capable of tackling problems which have never been encountered before;

(ii) to work on those problems which are of broad interest to a number of firms so that the industry in general will benefit and be advanced;

(iii) to undertake individual investigations where these would advance the general state of knowledge.

Group (iii) is of the lowest priority, and will only be undertaken during the formative stages of building up new industries or placing existing ones on a solid foundation.

The policy in a defence research organisation is broadly similar. The funds come from Defence sources and therefore the first priority on the resources is for

Defence needs. Here the requirements of the Services come first and the needs of the industries which work directly or indirectly for Defence follow. However, the laboratories are permitted to undertake work for non-defence industrial purposes where such work calls for special resources or facilities not available elsewhere. An unusual investigation under this heading was the Myer Music Bowl which was built in Melbourne recently. The construction was an entirely new departure and consisted of a huge canopy supported by a spider's web of steel cables. The main unknown was the effect of wind on the canopy. As may be imagined, an open construction like half a circus tent might flap or even become completely unstable in a high wind, even though properly anchored steel cables and metal covered plywood replaced rope and canvas. The problem was analogous to that of the aero-elastic flutter of an aeroplane wing, a phenomenon of considerable difficulty in high speed aeroplanes. A similar experimental technique was therefore used and a dynamically similar model constructed and tested in a wind tunnel at the Aeronautical Research Laboratories. In this case neither the special knowledge of aero-elastic phenomena nor a wind tunnel large enough to test a dynamic model were available elsewhere, and consequently the investigation was approved by the Chief Scientist of the Department of Supply.

conditions for research

In much that has been said, I have tended to bracket research with technical development and even with manufacturing efficiency. This has been because, with a few notable examples, Australian industry has not advanced very far on the road of originality. Nevertheless, the day will come when we aspire to leadership in certain fields and this will not be achieved without men of vision and originality of thought who are not content to accept the established order of things. Men of this enquiring type of mind are the real research leaders and have made the greatest contributions to technical progress. Generally, however, these very qualities make them rugged individualists and non-conformists to convention and routine. Management, particularly in America, tends to avoid employing them, which may be one of the reasons why so many basic new discoveries have been made outside that country. Notable exceptions have been the General Electric Company and the Bell Telephone Laboratories, both of which encourage individualists and, as a result, have been the pioneers of such innovations as modern discharge lamps and transistors.

However, there are in America dissenters from the current notions that large teams and giant equipment are indispensable to technological progress. Recently Dr. Tuve of the Carnegie Institute of Washington made a plea for the individual academic type of research. He pointed out that the Carnegie Institute subsidises ideas, i.e., the highly personal activity of the individual research worker. The basic principle is to buy a man's time and give it back to him. He must not have too many people interfering with his time or he becomes a manager. Again, his equipment should be smaller and less complicated than the best in his field, or again, he will become a manager or a constructor or a big-time operator. A moderate degree of austerity is essential to the hard work and disciplined self-criticism always required for creative intellectual accomplishment. Perhaps this very modesty in material requirements will encourage Australian industrialists to sponsor this kind of research which can truly be called voyaging into the unknown.

conclusion

We live in a scientific and technological age in which rapid changes and advances are taking place

Fig. 12. Myer Music Bowl, Melbourne.

and progressively gathering momentum. To become a great nation Australia must advance its industries with research. We have lived on borrowed fruits in the past and must learn to stand on our own feet. The day when overseas "know-how" could be purchased with a licence fee is passing now that Australia is beginning to compete with manufactured goods in the competitive world markets.

In research, industry cannot look to the Government laboratories to do all the necessary research—apart from the cost to the taxpayer, they are not an integral part of industry and cannot fully understand its problems. Management must, in fact, accept research as a normal function.

The problem of research cannot be divorced from the problem of obtaining the requisite numbers of scientists and technologists. Here again, we must look to our own Universities and Technical Colleges to train them, and present indications are that our capabilities in this direction fall far short of the demand. Thus, costly and wasteful duplication of effort must be avoided in our use of the men available and in this regard the three levels of research must be fully utilised and integrated.

Finally, I must reiterate that research — and this applies particularly to engineering research — is an important factor in productivity. Both U.S.A. and Russia, two countries in which productivity is a national aim, make wide use of research staff. For example, in the years 1953 - 57, the use of engineers and scientists in research and development activities by American industry increased 45%, whereas the comparable increase in the use of graduates in industry for manufacturing processes was 30%. Since U.S.A. is the Mecca for productivity teams from all over the world, this is an example we in Australia may well follow.

To conclude, I cannot do better than quote the words of Mr. R. G. Casey to members of the Institution of Engineers earlier this year. These might equally well have been addressed to this present gathering: "You represent a profession on which very largely depends the development and progress of this young country in the years ahead. Prosperity is not one of nature's free gifts to man. It is left to the engineering profession to turn natural resources into improved standards of living and of human satisfaction. In a troubled world you are the constructive element. I have no doubt that you will live up to the many responsibilities that are on you." No words of mine could conclude more appropriately.

acknowledgment

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THE PACKAGING OF ENGINEERING PRODUCTS

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ALMOST all metal articles, with the exception of very heavy assemblies and such things as motor vehicles which are delivered direct to the customer, are packaged in some way. The packaging material used may be simply in the form of steel strapping on bundles of steel rods or ingots, serving merely to keep a reasonable number of units together in a form in which they can be most conveniently handled, or it may be in the form of a complex assembly comprising an outer case, internal furniture of greater or lesser complexity, and corrosion preventives together with a desiccant. Such an assembly may need to be capable of protecting a delicate piece of equipment on a journey halfway round the world and subsequently in storage in an unfavourable climatic environment for a period of five years.

The former instance provides an example of a very cheap pack used by a steelworks to get material to a customer perhaps only a few miles away. The latter indicates a basic requirement of Full Standard Packaging for equipment supplied to H.M. Armed Forces [1].

Between these two extremes, there is a huge and diverse array of products, each of which poses its own packaging problem. It is the purpose of this Lecture to survey some of the problems involved and to indicate the principles to be followed in their solution. We shall try to see where the packaging function fits into the production cycle and to suggest some of the points which have to be considered in packaging various types of goods. We shall try also to describe the research which has been carried out into packaging problems and to show how research and testing methods can assist in the solution of day-to-day problems.

One of the major difficulties facing any writer on packaging is the diversity of the problems involved. Packaging is not an industry of itself; it is a *function* of almost all industries. Materials have been produced and methods devised to cope with their special needs. Each individual product brings its own packaging problems; there is no general solution which can be translated into a magic formula for successful packaging. Often the place of the operation in the production cycle is not recognised or clearly defined and responsibility for packaging often devolves upon some person whose main duties, in which he is primarily interested, have little connection with packaging. Often also, this person is not familiar with the voluminous literature on the subject or with the sources of general information. It will be one of the writer's aims therefore to provide general guidance and indicate where further information can be found, but the reader will readily see that any attempt to describe packs for particular products in a lecture of this kind can only result in chaos, or in a work the size of the Encyclopædia Britannica!

definitions and objects of packaging

It will be well in the beginning to state clearly what is meant by certain terms. B.S.3130, The Glossary of Packaging Terms [2], defines packaging as being all those operations involved in the preparation of articles or commodities for carriage, storage and delivery to the consumer. This definition will serve our purpose well. The term "package" is used to describe the complete entity, container plus fittings plus desiccant (if any) plus contents. The term "container" refers to the empty receptacle into which one or more items can be placed during storage and transit from producer to consumer. This last term has a slightly different meaning in the closely allied science of materials handling.

As to the object, it can be briefly stated that the object of all packaging operations is to ensure that the packaged article reaches the consumer in the best possible condition and it follows from elementary commercial considerations that the best pack is the one which achieves this object at the minimum *overall* cost. Such a bare statement does not tell us very much about why we package, but a little thought will suggest a number of reasons, depending upon the type of article under consideration. In the vast majority of instances, one very good reason is that the packaged article requires protection against the hazards of transport which are bound to be encountered in any distribution system. These hazards may be mechanical or climatic and all tend to lead to damage. They will be considered in some detail later on.

Another reason is that packaging can in many instances facilitate storage and handling both at the producer's works and by the consumer. To give an example, if one is producing electric irons it is much easier to stack them if they are in cartons than if they are not. A very common problem in engineering is the handling of a large number of spare parts. If a motor manufacturer brings out a new model, it may entail the addition of 2,000 spare parts to his range. Many of them will closely resemble the corresponding parts on other models but will not be interchangeable. Printed and stencilled packages can provide ready means of identification, as well as lending themselves to neat and tidy storage.

A third consideration is that most packaging materials can be attractively printed or otherwise adorned and in this way can contribute to the sales appeal of a commodity.

It is generally true to say that the major consideration in the packaging of engineering products is that of protection against damage. One generally buys such products because one wants to use them, not because one has seen them and would like to have them around, but there are many instances in which a customer has a choice of several models. An attractive package can influence sales in these instances. Rapid developments are taking place in marketing techniques and even the traditionally conservative hardware and ironmongery trades are now realising the value of attractive display. Products such as small tools and spares, which a few years ago were sold loose over the counter, are now packaged for display. If experience in other industries is any guide, that section of the engineering industry producing consumer goods will enlist the aid of sound packaging techniques to help fight the increased competition which is resulting from the transition from time of shortage to time of plenty.

Whatever the reason for packaging, it costs money, but it often costs less to do the job properly than to do it badly. The nation's packaging bill runs into hundreds of millions of pounds per annum and it is worthwhile doing one's best to see that the money is well spent.

the hazards of transport

All articles whether packaged or not will encounter certain hazards during distribution to consumer. Before any steps can be taken to design a pack for a given article some consideration must be given to these hazards of transport. They are :-

1. drops;
2. side impacts;
3. vibration;
4. compression;
5. climatic factors.

The first four constitute the mechanical hazards and can lead to structural damage to the packaged article. The climatic factors are those of temperature whether high or low, relative humidity and actual precipitation of moisture. In the field under review, high relative humidity is more important than low values and the climatic hazards usually must be considered from the standpoint of corrosion. Due regard must be paid to the effect of these hazards on the packaging material as well as on the packaged article. Quite frequently two hazards occur together as, for example, when a stack of packages is subjected to vibration during transit.

In the very early stages of thinking about packaging any article, one of the things which needs to be known is how the product is to be distributed — whether, for example, it is intended for the U.K. market or whether it will be sent overseas. It is generally considered that goods for export require a higher degree of protection than those destined for the home market. Extra handling is involved in the transfer of packages on and off the ship as well as on the dockside. Ports vary widely in the facilities which they offer for loading and unloading freight. A good deal of useful information on these facilities will be found in " Ports of the World " [3]. The larger shipping companies, too, are generally able to supply information. The climatic hazards are frequently much more severe abroad than in the United Kingdom. Temperatures and relative humidities are liable to be higher. Temperatures of 100°F, in combination with relative humidities of 90 - 95% with condensation at night, are frequently encountered. Information on climatic conditions in various parts of the world is freely available from the Air Ministry Records Division. Little is known about conditions inside ships' holds, though it is thought that temperatures of 160°F can occur in ships in equatorial regions. Under such conditions, coupled with salty marine atmospheres, corrosion proceeds very rapidly indeed and moisture barriers which appear quite adequate under United Kingdom conditions are often found wanting.

With regard to the home market, several distribution systems are in common use, and each has its own peculiar combination of hazards. It is generally accepted that packages distributed by manufacturer's own transport receive the best handling. This is after all reasonable; a person generally takes good care of his own property and if a driver knows that he will have to answer to his superiors for any damage in transit he will take more care. When a public carrier is employed one has the choice of road or rail, or in the case of smaller items, parcel post. This is not the place to make comparisons between the systems as to the severity of the handling involved and, indeed, there is not sufficient information available to do so, but it can be said that where it is possible to despatch full loads of one type of package direct to their destination, they will normally receive less severe handling than when they are sent as mixed goods traffic.

Damage to goods is more likely to arise when they are being handled than between handlings, and a recent conference sponsored by the International Cargo Handling Co-ordination Association has drawn attention to the fact that a typical package destined for export may be handled more than a dozen times, according to the following scheme :-

1. from packing shop into store at producer's factory;
2. from the store on to a lorry;
3. off-loaded from lorry on to dockside;
4. moved along quay to ship's side;
5. prepared for hoisting aboard by sling, net or hook;
6. hoisted into the hold of the ship and placed in the square of the hatch;
7. moved into storage position.

   The package is now in position for its sea journey and the sequence is reversed during unloading :

8. moved back into the square of the hatch;
9. prepared for lifting ashore;
10. lifted ashore and placed in pile on quayside;
11. moved along quay or into warehouse for storage;
12. loaded on to vehicle;
13. unloaded into warehouse at customer's premises;
14. taken from store for unpacking.

This is a perfectly straightforward example in which only the minimum number of handlings is involved. Where rail transport and transhipment are necessary the total can easily be increased to 20 or more. Similar handling programmes can be worked out for inland distribution systems. Private transport for example can cut the handlings to two — on and off the lorry. Rail transport usually entails at least six or eight handlings unless full loads can be despatched. It is essential to know what happens when packages are handled and it will be worthwhile to say something of the ways in which information on journey hazards can be collected.

assessment of hazards

The hazards can be ascertained by observation — that is by actually travelling over the route and watching what happens to a number of packages; or there may be records in existence, such as claims for damage, which will be some help; or it may be possible to employ packages containing instruments which will actually record impacts.

Direct observation suffers from three disadvantages — a large number of packs is required or alternatively many journeys must be made; it is costly both in time and money; the information gained is incomplete, for it is rarely possible to observe every handling and even if this can be arranged then, human nature being what it is, handling may not be the same when observers are present as when they are not; nor is it easy to inspect packages fully during a journey to ascertain when damage has occurred.

Similarly, the information available from records is nearly always incomplete in that they normally only reveal that damage has occurred and it is not always possible to relate this back to a particular hazard, nor can one gain much idea of the intensity of the hazard.

Fig. 1. Single Patra Journey Shock Recorder.

Undoubtedly the best way is by the use of instruments and several types are available which can be used to measure both impacts and vibration. Some care and experience is needed to interpret the results but much useful information has been gained, particularly with regard to the drop hazard. The type of instrument in use at Patra is illustrated in Fig. 1, which shows a single instrument, and Fig. 2, which shows a block of 24 mounted ready for insertion into a packing case. The instrument consists essentially of an oil-damped mass/spring system which can be pre-set to record impacts from a given height. The instrument is sensitive to duration as well as intensity of shock and some form of cushioning, usually polyurethane foam, is used to line the case containing the block of instruments.

Fig. 2. Block of 24 recorders ready for insertion into their case.

The instruments suffer from two main disadvantages. Firstly they will only record drops in one direction, and if set to record drops on, for example, the base and side faces of a case, then edge drops will be resolved into their vertical and horizontal components and may be recorded on two instruments as drops from a lower height. Corner drops may be recorded on three counters. The effect of this is to present a rather optimistic picture of actual conditions. Secondly, a block of 12 instruments weighs about 40 lb. and requires a container about 17 in. × 12 in. × 10 in., so that if one wishes to cover four faces of a package for three drop heights one is restricted to investigating road and rail transport systems. It is, of course, possible to use fewer counters and more packages, but the labour involved soon becomes excessive. In practice, Patra works closely with the transport authorities and packages containing instruments are sent over various selected routes as part of the normal parcels traffic, care being taken to ensure that the handlers are unaware of the contents. Handling varies considerably over different routes within a given system and even over the same route wide divergencies are found, so that in practice a large number of packages must be sent at different times. Such things as weight and shape of package, skill and temper of personnel, and facilities available at transhipment can all affect the handling which a package receives. Many factors have not yet been investigated scientifically and one can gain only a very general idea of their effect. Within limits, one can say that the lighter the package, the more severe the handling. Packages below about 28 lb. are liable to be thrown, especially when unloading from wagons on to a lower level. Packages between about 28 lb. - 112 lb. probably receive rather better handling. Packages from 1 cwt. - 2½ cwt. are usually handled by two or more men or mechanically. They may also be rolled end over end if their shape makes this easy, but drop heights tend to be lower than for lighter packages. Cases of greater weight are frequently mechanically handled which again leads to lower drop heights, except for those instances where packs fall from pallets or slings, though ramming with fork lift trucks is a not uncommon hazard.

Typical results obtained by the use of Patra Journey Shock recorders are shown in Figs. 3, 4 and 5.

Fig. 3 shows the number of drops of various heights suffered by 20 identical packages sent as part of a full load of goods between two towns in the British Isles. Fig. 4 is the corresponding distribution for packages sent by mixed goods traffic between the same two towns. It will be seen that not only did the packages forwarded by mixed goods wagon receive more drops than those sent as part of a full load, but the proportion of higher drops was increased.

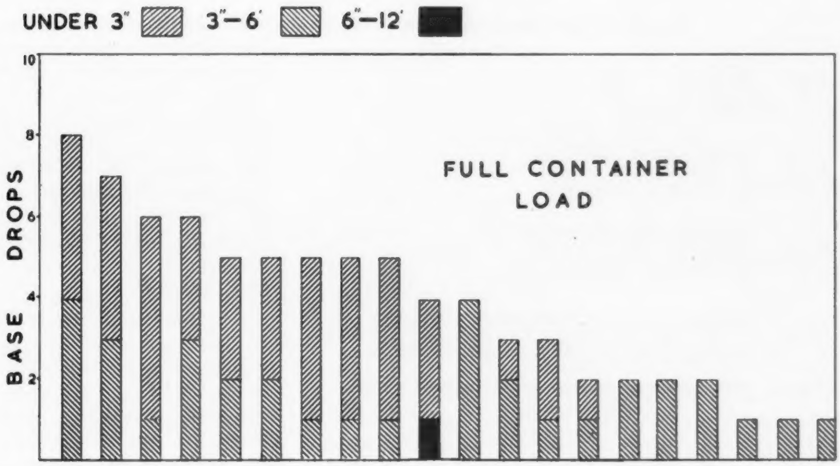


Fig. 3. Drop height distribution — full load.

Fig. 5 shows how the total number of drops was distributed over the six faces of the case. The package was approximately 17 in. × 12 in. × 10 in. The 17 in. × 12 in. faces are counted as top and bottom. In general, packages will travel on their largest face unless they can be stacked better in another position. Packages of abnormal aspect ratio, however, are frequently stood on edge and leaned against the side of the wagon.

Further information on the drop hazard is contained in Patra Laboratory Report Nos. 4 and 5 [4, 5] but it can be said here that drops above three feet are rare in home trades, though drops of seven or eight feet from slings may occur in export. A parachute drop is said to be equivalent to a free fall of 12 ft. - 15 ft.

side impacts

Side impacts or shunting shocks occur mainly in rail transit and some idea of their intensity can be gained from observation of shunting speeds. Velocities at the moment of impact are often of about 10 ft. per second. This type of impact occurs much less frequently in road vehicles but little information is available.

Measurements taken during braking tests on a saloon car [6] indicate shocks of about 1 g. - 1.5 g. Such shocks can also occur in aircraft during passage through turbulent conditions and on take-off and landing. A few measurements have been made on equipment destined for the Services, but results have been variable. Side impacts should not occur in ships if the cargo is well stowed.

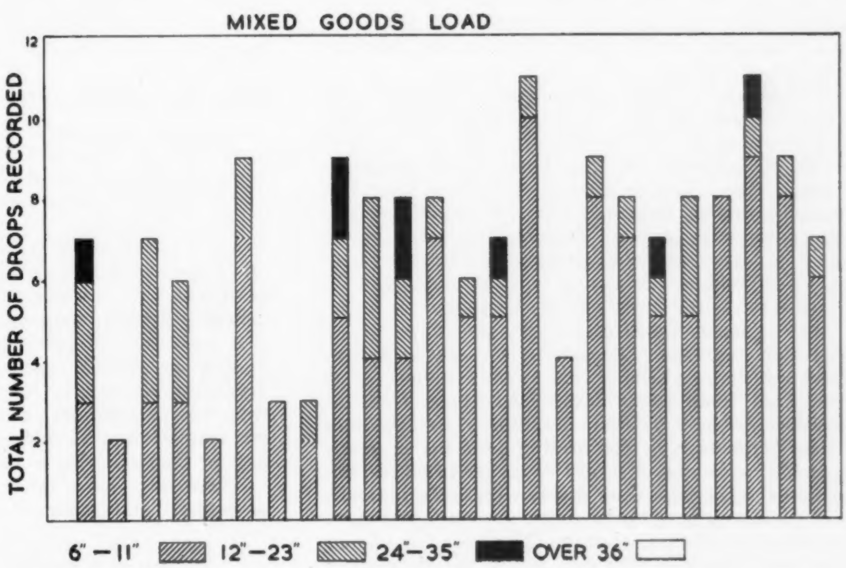


Fig. 4. Drop height distribution — mixed goods traffic.

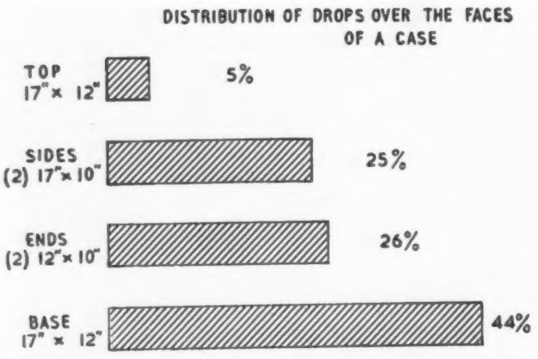


Fig. 5. Distribution of drops over the faces of a case.

Here again instruments are available which can be bolted to the floor of wagons to provide a record or shunting shocks.

vibration in transit

Whilst the information about the drop hazard is incomplete, that concerning vibration is sketchy indeed. Very few measurements have been made to assess the amplitudes and frequencies likely to be encountered. Some figures for various types of transport have been quoted by Schuler [7] and Miller [8]. According to Schuler, rail wagons give rise to vibrations having dominant frequencies about 100 cycles per sec. but lower frequencies are also important. With regard to road vehicles, Patra is undertaking some work in conjunction with the Motor Industries Research Association at the latter's test track at Nuneaton, but the work has not progressed to the point at which anything useful can be published. Suffice it to say that amplitudes are generally thought to be smaller than in rail wagons. Vibrations are excited by the engine of the vehicle and also by unevenness in the surface of the road. Indications are that the latter are of greater importance than the former.

Vibrations in ships at sea, excited mainly by the propellers and engines, are probably within the frequency range of 5 - 20 cycles per second, with amplitudes of ± 0.05 in. or less. There is no reason to suppose that vibration constitutes a major hazard in seagoing vessels, though it may, of course, be continued for long periods. Measurements taken in the body of cargo carrying aircraft indicate vibrations at 10 - 500 cycles per second with amplitudes up to ± 0.008 in. at the lower end of the frequency range.

The figures can only give a very general picture of vibration in transit. The pattern will obviously vary from vehicle to vehicle as well as with changing road and track conditions. Enough evidence is available, however, to indicate that vibration is an important cause of damage in engineering products of many types. Whereas the effects of drops are often obvious on casual inspection, those due to vibration are usually more insidious and furthermore, are often the cause of intensifying impact damage. The loosening of nuts and bolts, the failure of spot welds, the abrasion of painted or polished surfaces are well-known examples. It may also happen that resonant frequencies of the packaged article are encountered when the effects can be very severe, often leading to structural failure.

The techniques for measuring amplitudes and frequencies of vibration are generally well-known but their application to problems of packaging has only just begun. An interesting account of the importance of vibration in the packaging of guided missiles is given in "Materials Handling Engineering" [9].

compression

An indication of the compression hazard which any package may be expected to meet can often be gained from the headroom in warehouses and ships' holds. Stacking heights of 18 ft. - 20 ft. are not uncommon, depending upon such things as weight, shape and size of package. In the case of full loads the compression hazard is, of course, directly computable, but in mixed goods systems this is not so. In addition, it must be remembered that the load may not be squarely superimposed. Especially is this so in the case of packages of abnormal aspect ratio, for example, long cylindrical objects. Where an article is to go into store, the load may be applied for long periods, leading to "fatigue" effects in some types of packaging material, such as fibreboard. A theoretical treatment of "fatigue" in corrugated fibreboard cases is given by Brynhildsen and Dagel [10]. The compression hazard is not often important where wooden cases are used, though it may intensify the effects of vibration when the two hazards occur together.

Though knowledge of the expected hazards is by no means complete, some attempt must be made to assess them, and the best results in terms of economic cost will only be obtained when the assessment is accurate. When the assessment has been made consideration can be given to the ways in which the required protection can be provided. It will be convenient to deal separately with protection against corrosion and mechanical hazards.

protection against corrosion

In considering corrosion in packaging, it is usual to distinguish between "temporary" protection and what may be called the "normal" protection of metal surfaces. The protection involved in packaging is of a "temporary" nature, that is, it is usually removed before using the equipment. Do not be put off by the fact that in certain instances storage periods of up to five years may be envisaged before the article is brought into use. "Normal" protection is that provided by painting, galvanising or electroplating and similar processes. Its purpose may be decorative as well as functional. The distinction is that it is not normally removed before the article is put into service, nor is it generally considered to be part of the packaging material.

There are four main causes of corrosion of packaged metal articles. These are :-

1. inadequate protection against the climatic hazards of transport;

2. inadequate protection against the mechanical hazards of transport, leading to structural failure of containers and subsequent ingress of moisture;
3. corrosive properties of the packaging material itself;
4. inadequate cleaning and/or recontamination between cleaning and applying the necessary protective agent.

There are a number of ways in which the effects of these causes of corrosion can be minimised. Table I gives a somewhat simplified picture of the relations between causes and preventive techniques.

TABLE I

Inadequate climatic protection

Inadequate physical protection
Moisture barrier damaged

Other contaminants + ingress of moisture as
(i) salt spray;
(ii) rain;
(iii) high humidity and condensation

Corrosion control by protectives

(i) Packaging materials — control by specification

(ii) Industrial atmospheres —

Sulphur dioxide
Nitrogen peroxide
Carbon dioxide
Ammonia
Process residues
Dust and dirt
} Control by cleansing

It is important to realise that corrosion can occur in the presence of water vapour and oxygen whether contaminants are present or not. Since it is virtually never practicable to exclude oxygen from a package one must attack the problem in one of two ways, namely, either by preventing access of water or rendering it harmless once it has entered. Barriers are available which will keep out practically all water and water vapour from packaged items and inhibitors can be obtained which will inhibit oxidation of the metal surface. Between these two extremes there are many intermediate stages; some of the ways in which protection is provided in practice are as follows :-

1. prevention of access of moisture

(i) *barrier material*
Common barrier materials are metals and metal foils, plastic films, waxed and bitumenised papers and laminates, and to a lesser extent glass.

(ii) *barrier plus desiccant*
The common desiccants are silica gel, activated alumina, various complex alumino-silicates and quicklime.

(iii) *strippable coatings*
Certain plastic films can be applied by dipping, or less often, by spraying, to form an impermeable non-adhesive coating for the item.

2. inhibition

(i) *hard film*
Consists of a film of protectives, such as certain resins, which can be dissolved in a volatile solvent and applied by spraying or dipping, the solvent being allowed to evaporate.

(ii) *soft film*
Various grades of soft film are available which can be applied by spraying, dipping or brushing. They contain corrosion inhibitors dissolved in a non-volatile solvent such as mineral oil.

(iii) *contact inhibitors*
Both hard and soft films are examples of contact inhibitors, but there are other substances such as sodium benzoate which can be impregnated into paper which will then be used for wrapping of metal parts.

(iv) *vapour phase inhibitors*
Consist of substances which will emit volatile vapour which will inhibit corrosion. Dicyclohexylamine nitrite and cyclohexylamine carbonate are the best known examples.

selection of the preventive

The first step to be taken in preventing corrosion is to ensure that the article is clean. It is not intended to deal exhaustively with methods of cleaning, for excellent accounts already exist in the literature [11, 12, 13]. One point which must be made, however, is that all cleaning must be *thorough*. Whilst this may seem elementary, all subsequent treatment is rendered ineffective if this rule is not observed. Many failures which have initially been blamed on other causes can, in fact, be traced back to inadequate cleaning.

Consideration of the article to be packaged and its destination will usually indicate the preventive method to be used, but it will be necessary to take a closer look at some of the materials available and to give one or two examples.

soft and hard film preventives

These comprise a group of materials ranging from thin mineral oils containing an inhibitor to thick greases and hard resins.

Many of them have been prepared for special purposes such as application to certain metals and are covered by Government Specifications, which enable them to be used for packaging supplies for the Armed Forces. Their range of use is chiefly for spare parts, gears and simple assemblies, external working parts of engines, internal surfaces of gear boxes and hydraulic systems.

barriers

It has already been stated that moisture barriers are available which will keep out practically all moisture and moisture vapour. The ones most commonly used are :-

(i) paper laminated with wax or bitumen;
(ii) a plastic film, such as polythene or P.V.C.;
(iii) metal or metal foil.

The bitumen kraft laminates have a permeability usually between 4 - 30 gm./sq. metre/24 hours at tropical conditions (38°C, 90% R.H.). From this the amount of moisture vapour passing through the material itself can be roughly calculated for any package, but it is important to remember that a case liner cannot be formed from one sheet without joints and even with good sealing, the joints are always the weakest points. Frequently some three or four times as much moisture enters through the joints as through the walls themselves. Particular attention must therefore be paid to sealing techniques.

The kraft laminates are tough materials reasonably resistant to tearing and puncture during transit. If additional toughness is required, a jute scrim may be incorporated between the layers of paper. It is also possible to buy bitumen-impregnated paper which has similar properties to the laminate. In general, bitumen papers are to be preferred to waxed kraft since the latter frequently cracks on folding and creasing with disastrous effects on its permeability. A wide range of qualities is available, the material being specified by total substance and weight of bitumen. In general, of course, the greater the weight of bitumen the lower is the permeability, though it is important to ensure that the bitumen is properly spread over the whole sheet.

Plastic films for packaging are available in gauges ranging from 0.00075 in. - 0.010 in. The commonest gauges are 0.0025 in., 0.005 in. and 0.01 in. with a permeability from 1 gm./sq. metre/24 hours up to 10 or 15 times that figure. The most satisfactory way of closing these liners is by heat sealing. Polythene, P.V.C. rubber hydrochloride (" Pliofilm ") and polyvinylidene chloride (Saran) are all thermoplastic and heatsealable. The other packaging films, namely the cellulose group, polyesters and polystyrene, are not at present used to any extent as case liners or as direct wraps for the type of product under consideration.

A recent development has been the coating of polythene on to kraft paper, giving a material which combines the toughness of kraft paper with the useful heatsealability of polythene. Early samples gave variable results owing to indifferent coating techniques, which allowed cellulose fibres from the paper to protrude through the plastic film, leading to " wicking ", but this defect has been largely overcome, and coatings of the order of 0.001 in. or less are readily available.

Metal barriers are, of course, the most impermeable of all in an undamaged state. It is worth emphasising this point because susceptibility to damage in transit is an important point. Aluminium foil can readily be laminated to paper and plastics to provide an almost impermeable barrier. It can also be given a heat seal coating which will provide an effective closure. Special care must be taken during folding and creasing to avoid cracking the foil. Where large assemblies are to be protected, a metal sheathed case or crate can be used, the metal pieces being joined by soldering. It sometimes happens, however, that during transit the joints break down, under impact loading or vibration, and much of the effectiveness of the barrier is lost.

desiccated packs

It frequently happens that one is faced with the problem of packing items which cannot be coated with a greasy substance. Many scientific instruments and electrical goods are examples. In such instances the only satisfactory solution may be the desiccated pack. The principle of the desiccated pack is based on the well-known fact that metallic corrosion proceeds very slowly in relative humidities below 60%. The object then must be to enshroud the packaged item in an atmosphere whose relative humidity is below this figure. This is achieved by employing a barrier of known moisture vapour transmission rate and within this sealed barrier a desiccant of known absorptive capacity. If one then knows the size of the package, it is possible to calculate how long the relative humidity inside the pack will remain below a given figure in any given atmospheric conditions. As a safety precaution the generally accepted figure for maximum permitted relative humidity is 50%. Desiccants must be contained in suitable containers, so that dust does not spread throughout the pack. For convenience of calculation, a " basic desiccant " has been defined as a material having a moisture absorptive capacity of 27% of its dry weight when operating in an atmosphere of 50% relative humidity at 25°C. Absorptive capacities of all commercial desiccants are related to the hypothetical material. If one knows the conditions to which the package will be exposed during transit and storage, it is possible to calculate the quantity of basic desiccant required to achieve the desired result. The necessary calculation is set out in Appendix 1. It is worth mentioning that practical considerations limit the suitable barriers to those having a moisture vapour transmission rate of around 1 gm./m^2/24 hr. at tropical conditions, otherwise the quantity of desiccant becomes exorbitant. Barriers suitable are metal foil, 0.020 in polythene, metal plate in the form of hermetically sealed containers, and strippable coatings. As an extreme example of a desiccated pack, it was recently reported that a large jet aircraft was enclosed in a cocoon with six tons of desiccant in its interior!

The design of a desiccated pack requires some care. The volume must be kept as small as possible, the desiccant must be properly distributed in small units, and the quantity of dunnage must be kept as small as possible since cellulosic packaging materials and even wood itself contain up to 20% of moisture. Frequently, the dunnage requirements account for the majority of the desiccant.

vapour phase inhibitors

The use of vapour phase inhibitors for the prevention of corrosion was described by Stroud and Vernon[14], who described experiments with dicyclohexylamine nitrite (DCHN) and cyclohexylamine carbonate (CHC). Their use is described briefly in

B.S. 1133 Section 6, where vapour phase inhibitors comprise category T.P.8 of the temporary corrosion inhibitors. It is important to note that there is no corresponding category in D.E.F.1234 [1]. Owing to their differing vapour pressures DCHN and CHC have rather different spheres of action, which have been discussed by Lloyd Evans and Stroud [15]. Great care is necessary in selecting the appropriate materials for any given use, and many reports in the literature are conflicting. The confusion mainly arises from the fact that the inhibitors can actually cause corrosion of some non-ferrous metals and there is some evidence that they can also attack certain plastic materials. Rance and Cole [16] have summarised some of the evidence available on these points. Briefly, DCHN may be aggressive towards magnesium, zinc and lead, while CHC may attack copper, its alloys and magnesium. CHC will in some circumstances attack cellulose nitrate [17], and DCHN will cause colour changes in paints.

Doubt has been expressed about the ability of V.P.Is. to resist corrosion once started, though CHC certainly stops corrosion of mild steel that has been started by sodium chloride, a frequent constituent of packaging materials.

The commonest form in which these materials are met with in packaging is as a coating on paper, which can be placed inside a sealed package to prevent corrosion. DCHN is much less volatile than CHC and is consequently effective for a longer time. Care must be taken that the vapour can reach all parts of the pack. This normally implies that the inhibitor must be strategically placed throughout the pack, and the package must be adequately sealed to prevent escape of vapour. Within their limitations there is no doubt that vapour phase inhibitors are useful additions to the range of corrosion preventives. An example of their use which has recently come to light is the protection of car bodies for shipment to Australia [18]. Car and truck bodies are shipped knocked down in sheathed plywood cases. It is stated that satisfactory results have been obtained with a minimum of one square foot of the paper per cubic foot of case, provided that all parts are within 12 in. of the inhibitor paper.

Whatever form of temporary corrosion preventive is adopted, it is essential that it should be applied as soon as possible after manufacture. Corrosion once started is often very difficult to stop, especially in the case of cast iron. Articles often go into store for a period before being packed for despatch. External surfaces may have been painted or plated, but other surfaces, unseen, may be unprotected. It is possible to argue that this is no concern of the packaging department, but they are responsible for seeing that the product reaches the customer in perfect condition. They will get the blame if it doesn't!

corrosion by packaging materials

The foregoing paragraphs have dealt with the various corrosion preventives and the next section will say something of the methods of providing protection against mechanical hazards, but before leaving the subject of corrosion there is one topic which is worth some discussion, namely that of corrosion caused by packaging materials themselves, for in such instances special care may be required if the effect of other corrosion preventives is not to be nullified.

The best-known examples are of corrosion caused by excess chloride and sulphate ions in paper, board and adhesives, but many species of timber give off quantities of acid vapours or corrode metals in contact with them. During the paper making process various bleaching agents containing chloride may be used, in addition to aluminium sulphate. The water used by the mill, too, may be impure, as for example, where a mill stands on a tidal estuary. Complete absence of chlorides and sulphates cannot be expected, but it has been found by experience that if papers are neutral (pH 5 - 8), with chlorides below 0.05% as NaCl and sulphates below 0.25%, as Na_2SO_4 corrosion will not in general occur.

Board is usually more difficult to control than paper, since it frequently contains waste pulp of unknown origin. Corrugated board, too, is often bonded with alkaline sodium silicate. Casein glues or wet strength ureaformaldehyde glues and resins may also give rise to trouble, as may adhesives based on polyvinyl chloride. It is often more convenient and cheaper to ensure that board does not come into direct contact with metallic articles than to insist on chemical purity.

Rance and Cole [16] have quoted examples of corrosion caused by organic vapours from wood.

Materials such as desiccants may need to be checked for purity. The alkaline nature of quicklime is well-known, but silica gel and alumina can contain alkaline impurities. These materials may be specified by reference to B.S.2540 [26] and B.S.2541 [27].

In general, then, when ordering packaging materials consideration must be given to the possibility of their coming into direct contact with metals and causing corrosion. If contact is expected it may be necessary to specify certain limits for impurities.

practical examples

Finally, it might be useful to quote one or two practical examples.

If one is packing a calculating machine which is to be sent to South America it is obviously quite impossible to use any of the soft or hard film preventives, or strippable coatings, for it is not possible to obtain adequate coverage of all the intricate parts. Contact inhibitors too would present difficulties. The choice lies among a barrier alone, barrier plus desiccant or vapour phase inhibitor. Reference to climatic data for the port concerned will indicate whether a barrier alone is sufficient, or whether a desiccant must be included. Vapour phase inhibitors should be tested before use since the machine will probably contain alloys of non-ferrous metals. Some products, such as tools and unassembled spares, permit a wider choice. Here hard or soft films, strippable coatings, contact or vapour phase inhibitors are all possibilities. Desiccated packs, while suitable technically would probably be ruled out on the grounds of expense. Whilst it is folly to look upon

corrosion prevention solely in terms of pounds, shillings and pence, the economic aspect of packaging must never be forgotten.

protection against mechanical hazards

The previous section has briefly described the available methods of protecting articles against corrosion caused by the climatic hazards. In this section it is proposed to deal in very general terms with the methods of providing protection against the mechanical hazards. Broadly speaking, two components of the package are involved, namely the outer container and the internal fitments.

outer container

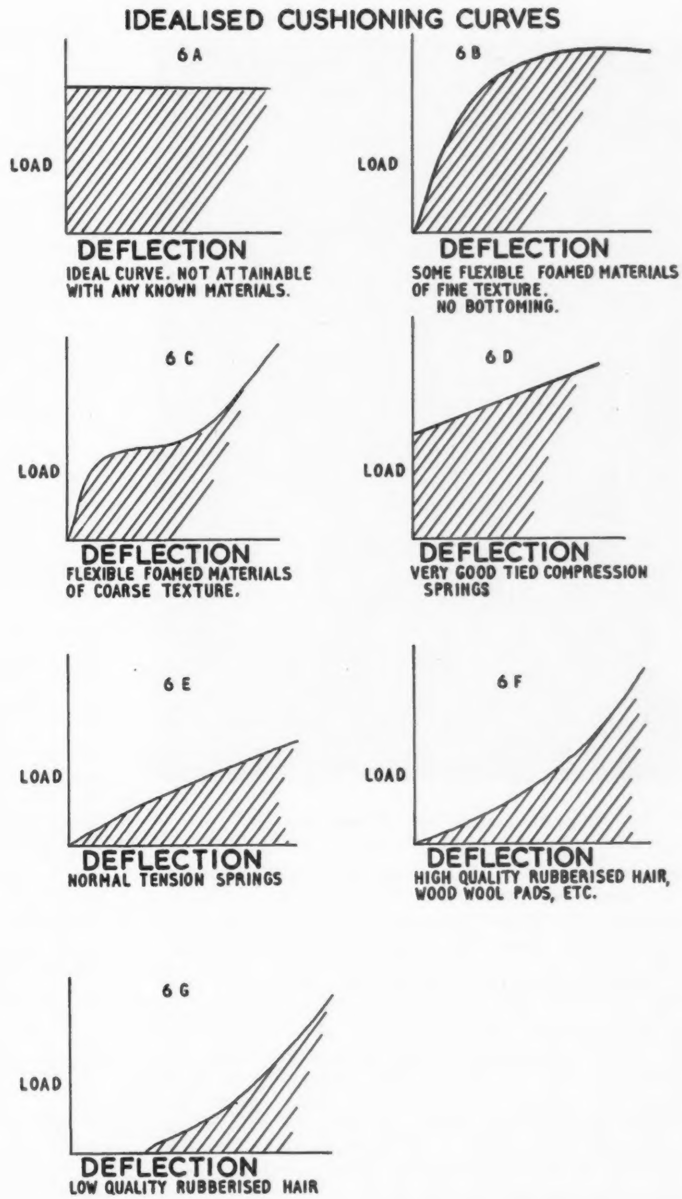
The vast majority of outer containers today are made either of wood or fibreboard, though other materials such as metal, plastics and fibreglass are used to some extent. They cannot however compete with wood and paper on terms of price for the bulk markets. Before the War, timber was cheap and manufacturers could afford to use wooden cases of high quality, often on a returnable basis, but nowadays timber is expensive and many people have turned to fibreboard as an alternative material. The change over has been accelerated by a number of factors.

Firstly, there is a tendency for the unit of bulk distribution to be reduced in size to facilitate manhandling. Even where mechanical handling is available, loads are made up of a number of units each of which can be distributed without further overpacking when the bulk load is broken down. Secondly, labour has become an expensive commodity and it is not economic to use returnable containers with all their attendant clerical work of checking in and out, except in very special circumstances. Thirdly, fibreboard offers an initial price advantage and where carriage is charged on gross weight or cube, there is often a substantial saving in freight. Fourthly, there have been improvements in the quality of fibreboard which have not been paralleled in the field of wooden containers. Finally, the fibreboard manufacturers have adopted a very aggressive and competitive marketing policy which, coupled with the research and testing facilities which they can offer, has enabled them to capture many of the traditional markets for wood.

The details of design of containers in either wood or fibreboard lie outside the scope of this lecture. Much useful information on both corrugated and solid fibreboard is contained in Section 7 of B.S.1133 already referred to, whilst Section 8 gives similar information for wooden containers. The interested reader will also find much valuable data in books by Plaskett [24] and Stern [25]. It might perhaps be helpful to summarise in a general way the effect of the various hazards of transport on wooden and fibreboard containers.

HAZARD	WOODEN CONTAINER	FIBREBOARD CONTAINER
Drops	Both types of container can be built with reasonable resistance to drops but fibreboard cases, being more flexible, are often more resistant to breakage than wooden cases.	
Shunting Shocks	Damage to the product from this cause is usually dependent on the internal packing and the type of outer is not very important.	
Stacking	Virtually unaffected at all heights of stack likely to be encountered.	Stacking resistance limited and construction of container must be such as to give safety in some instances up to 20 ft. high.
Vibration	Dependent on type of construction. Some containers can be adversely affected.	Little effect on containers in general.
Vibration Under Stacking Loads and during Transport.	Dependent on type of construction.	Usually little effect on container unless weight becomes excessive.
Humid Conditions	Little practical effect.	Considerable effect which can cause great weakening in respect of stacking and impacts.
Showers	Little practical effect.	Results in considerable loss of strength.

Fig. 6. **Compression performance curves of idealised cushioning systems.**



In general both fibreboard and wooden containers are shock absorbers though both deform extensively on impact, which may result in considerable local stresses on the packaged object. High-speed photography has shown that wooden boxes and crates tend to distort diagonally by racking of the joints, but that almost all the initial distortion may be reversible. During one series of tests at Patra, a wooden box 17 in. × 12 in. × 10 in. was filled to a weight of 20 lb. and dropped from 4 ft. 6 in. on to a concrete floor, so as to fall on to a corner. The maximum displacement of the base boards relative to one another was about 1½ in., owing to racking of the joints, but the residual distortion was virtually nil. A fibreboard box of similar size and weight, when tested in the same way, showed localised crushing of the corner but practically no diagonal distortion.

It is thus quite conceivable that the two types of container can result in quite different stresses being imposed on a packaged object. The important point is, however, that no matter how rigid a container may appear it is seldom safe to assume that it will not deform on impact. Similarly, the parts of a packaged article itself may move relative to one another, and the thinking involved is how to minimise the effect of the imposed stresses and bring the packaged article to rest without damage. Ususally this absorption of shock is achieved by various internal fitments or cushioning materials.

cushioning materials

The materials available for use as internal fitments are many and varied, from wooden battens or simple fibreboard pads and dividers, to foamed and expanded plastics and rubbers of many types. Corrugated fibreboard itself is a very good cushioning material in some circumstances and it can be built up into multilayer pads which are available in many sizes and qualities. Wood wool is another useful material which is both versatile and cheap. It can be used either loose or in the form of pads moulded to fit specific articles. Other materials of similar nature are paper shavings, packaging felt, various compressed fibrous boards similar to building boards together with coir and hair pads. Hair is nowadays often sprayed with rubber, which gives it greater resilience and improves bonding of the pads.

More expensive, but often more efficient, are the cellular rubbers and plastics which are available in weights and grades to suit many purposes. By reason of their higher cost they are principally of interest to manufacturers of expensive and delicate equipment, and to people engaged in packaging for the Armed Forces. Care is needed in selecting the right material according to the expected conditions of service, for some of them are affected by temperature,

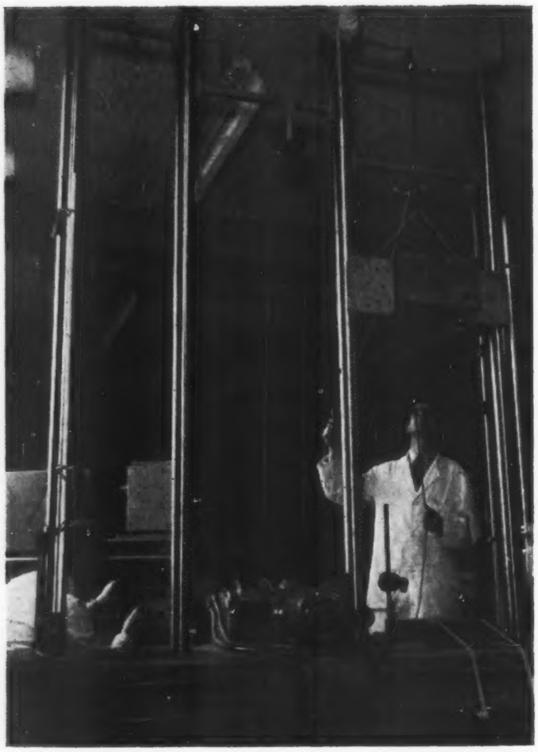


Fig. 7. General view of drop hammer.

often acquiring a " permanent set " with great loss of cushioning power. For example, it is not yet possible to obtain materials which will perform satisfactorily under both high and low temperatures.

Another form of cushion is the ordinary tension spring, which can be used to suspend an article inside a container and which will control its movement upon impact. Frequently coiled springs are used in matched pairs attached to opposite sides of the object; or the packaged object may be inside a small inner container to which the springs are attached, the springs serving to suspend the whole in the larger outer containers. In the case of heavy or fairly robust assemblies, leaf springs may be used.

It is not the intention to deal exhaustively with the multitude of cushioning materials which are available. Many of them have been designed with special applications in mind and details of performance can best be obtained from the manufacturers. General guidance on the selection of suitable cushioning materials is given in Section 12 of B.S.1133. It may, however, be appropriate to make clear what is the object of package cushioning, and to outline the general characteristics of the various systems.

Cushioning material is defined in B.S.3130[2] as " the material applied to mitigate shock and/or to protect surfaces from abrasion and/or to position an article in a container ". The primary purpose of cushioning material is to reduce the shock to which the contents of a container may be subjected to below the level at which appreciable damage may occur. The shocks may be in the form of large intensity occasional shocks from drops and impacts, or small repeated shocks from vibration.

The main properties of cushioning materials, on which their usefulness depends, are compressibility and resilience. Compressibility must be such as to allow a reasonable movement of the packaged articles to take place so that the shock can be dissipated. Too hard a cushion results in too high a shock being transmitted and too soft a cushion means that the thickness required will be unduly large. Resilience is necessary to ensure that the cushion recovers after compression, ready for the next shock.

The selection of appropriate cushioning for a given article depends upon such factors as the size, weight and fragility of the article and the hazards to be expected. Fig. 6 shows the shapes of the compression performance curves for various idealised systems. The energy absorbed is indicated by the area under the curves.

It is apparent from the curves that each material has a range of use within which it is most efficient. Consequently, in selecting a cushioning material it is necessary to be able to predict how it will behave under dynamic rates of loading. The prediction cannot always be made from static load/deflection curves and recourse must be had to measurements under shock loads. The apparatus used to make these measurements is called a drop hammer, and the one in use at Patra is shown in Fig. 7.

The apparatus consists essentially of a mass (the hammer) which can be raised to a given height above a concrete block, on which rests a pad of material under test. The hammer carriers a barium titanate accelerometer from which an acceleration/time curve can be obtained as the deflection of the spot on the screen of a cathode ray oscilloscope. Arrangements can be made for the trace to be photographed as a permanent record. Fig. 8 is a diagrammatic representation of the set-up.

Once the appropriate measurements have been made on the cushioning material selected, it is *in theory* possible to design a package for any article such that a given " Fragility Factor " will not be exceeded for a given drop height. The fragility factor is the shock level which an article can be expected to withstand without breakage. It is usually stated in terms of "g", this being of course the acceleration due to gravity. Thus a fragility factor of 40g means the article concerned can be expected to withstand an acceleration 40 times that of gravity before breakage occurs.

The reservation " in theory " must be made because there will usually be a number of unknown factors. Firstly, the shock and vibration conditions to which a package will be subjected in transit will not, in general, be known with any great precision so that an estimate must be made.

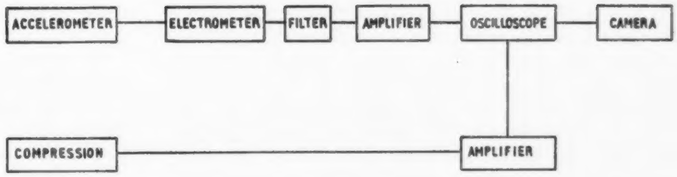


Fig. 8. Diagram of drop hammer system.

Secondly, the fragility factors may not always be known. It is only possible to determine them by experiment, which in the case of expensive items of equipment can be costly, especially if, as is usually the case, the scatter is wide. Values ranging from 40g - 100g have been reported for apparently identical pieces of equipment. The fragility factor is not the only consideration. One needs to know the maximum permitted deflections and resonant frequencies of the various components and assemblies.

The pulse duration is just as important as its intensity. One piece of apparatus tested at Patra was said to be sensitive to shocks of 40g. A test piece broke when dropped on to a 3 in. pad of polyurethane, which resulted in a shock of 44g for 29 milliseconds, indicating that under these conditions the fragility factor was not far out. However, when the article was dropped on to corugated fibreboard pads resulting in a shock of 99g for 9 milliseconds, no breakage occurred. Thus the peak acceleration is not the only consideration to be taken into account. The pulse time must be considered as well.

Thirdly, the influence of the container itself on overall shock transmission has to be taken into account. Cushioning material may have to deal not only with the energy of the contents, but also with the rebound energy of the container. It has already been pointed out that the container itself may be a good shock absorber.

Fourthly, little is known as yet about what may be called the "shape factor" of the bulk cushioning material, that is, the effect of such things as cut-outs, cavities and joints in mouldings. In sealed containers there may also be an effect due to air in the cushioning material and in the cavities.

Lastly, the behaviour of cushioning material has been measured by subjecting it to flat impacts. Little is known of its behaviour when subjected to edge or corner drops.

The mathematics of package cushioning becomes very complicated indeed if all these things have to be taken into consideration. Very good accounts of the dynamic aspects are given by Mindlin [28] and Brown [29], but the stage has not been reached when the ideal package can be designed by formula.

So far this section of the Paper has been concerned mainly with impact damage, by which one tends to think of breakage of comparatively large members, as a result of drops or side impacts. Protection against vibration can be equally important. Care must be taken that polished surfaces are not in contact with rough edges. Incredible though it may seem, examples have been seen at Patra in which strips of rubber, intended as anti-vibration mountings, have been fastened to a case side with large screws, the heads of which were left projecting against an enamelled surface. Needless to say, considerable damage resulted.

To sum up, adequate protection against mechanical hazards should be obtained if the problem is tackled in the following stages:-

1. Examine the product and where appropriate decide on the best support points. Designers of equipment can help by providing adequate mountings for assemblies, and keeping projecting parts to a minimum. They should also provide adequate pick-up points on equipment for impact loads in transit, a point frequently overlooked by designers in their aim to keep production costs down.
2. Note any fragile parts and if possible determine the fragility factors. Again, designers may be able to help by providing extra support at weak points.
3. Study the internal handling conditions and the distribution system to gain an idea of what the mechanical hazards are likely to be.
4. Try to get specimen packs from several possible suppliers. Where appropriate try out different possible cushioning materials. Carry out a few simple tests on a prototype package.
5. After that stage it should be simply a matter of eliminating faults, checking and improving until the desired damage level is achieved.

These five steps in fact form a large part of the work of a packaging engineer, and a few thoughts on how to set about them are contained in the next section.

the place of the packaging function in production and marketing

In an industry so diverse as engineering it is understandable that managements should differ in their outlook on packaging. Some regard is as an integral part of production and to them packaging costs are a legitimate part of production costs. Such firms usually feel that a well-designed and attractive-looking pack is indicative of a good product. The pack is, after all, the first thing which the customer sees on receiving the goods, -and one which is adequate and well-designed without being wasteful creates a favourable impression in the customer's mind. It suggests that thought has been applied to the problem and it is reasonable to suppose that similar thought has been given to the design of the product.

There is also the other extreme which regards packaging as a nuisance, to be done as cheaply as possible, with little regard to the needs of the product.

Such firms usually have high damage claims and high insurance premiums, but they prefer to replace damaged items rather than spend money on providing adequate protection. They perhaps rely to some extent upon the traditional reluctance of the public to complain, though there are signs that the public is becoming far more critical of slight damage than it used to be. In the early post-War period one did not complain too loudly about scratches or polished surfaces. All too often one counted oneself lucky to get what one wanted at all, and so long as the article functioned without too much trouble, one kept quiet. Such is not the case today. If an article is not up to standard it is easy to get a replacement and probably also take one's custom elsewhere next time.

There can be little doubt which is the right view to take. Customer goodwill is a vital asset, especially in the export market. Here, even if a damaged article or part is replaced, there must inevitably be a delay before it reaches the customer and replacement has done little or nothing to enhance the customer's opinion of his supplier. It is true that the carriers or the insurance companies will pay the bill and the supplier may not be out of pocket this time, but his chances of getting further orders have been diminished. The insurance company, too, will be watching the premiums. The increasing interest being shown in the Institute of Packaging educational courses is a measure of the importance which companies attach to packaging.

who selects the pack ?

It has already been stated that the prime object of packaging is to protect the product during transit from producer to consumer. Whatever a Company's outlook may be the cost of packaging will have to be taken into account. Like all other costs it can be kept to a minimum by careful planning, and co-ordination of all the departments concerned. Let us briefly look at the way in which the various departments fit into the picture. Firstly, the management can be likened to general headquarters. They are concerned with policy, markets and finance. They view the production and sales operation as a whole. They are not to be worried by details, but they must co-ordinate the activities of all other departments and iron out any difficulties and anomalies, on the advice of the departments concerned. Secondly, the sales and marketing departments must have their say, since they know what the product is required to do, what the markets are, for example whether the product is destined for home trade or export, whether it will be sold by retail to the public in competition with other similar brands, whether it has the market to itself, or whether it will be sold principally to merchants and similar people. These things will all affect the choice of package.

In general, the sales people will class the product in one of three groups, as follows :-

1. portable goods that have a shelf appeal, e.g., electric irons, electric razors, where an attractive pack is important to catch the eye of potential customers;
2. portable goods that cannot be put on the shelf in the pack, such as electric or oil stoves, cookers, etc., where the pack needs to be reasonably attractive but decoration is of secondary importance;
3. heavy machinery where the pack is purely functional.

In some instances visibility is important, as for example in the packaging of small spares, where the bubble pack, a combination of paper and plastic sheet, has been so successful. It frequently happens that people do not know the correct name for a spare part and shrink from trying to describe it. If they can see it on display they will buy it. The marketing people will also know the way in which the product is to be distributed, for example by road or rail. The choice of system will affect the pack.

Thirdly, the production department will need to be consulted, since they will want the flow of the product through the works to be as smooth as possible. They will want the product to fit into the existing set-up to keep special tooling costs to a minimum; thus they will want to be consulted about details of design, which may of course, affect the design of pack.

Fourthly, the costing and buying departments will know how much money is available for packaging. They should know all about the costs of the product and must take into account not only the material costs of the pack but also the cost of labour required for package assembly and closure. In many instances this item can substantially increase packaging costs.

Fifthly, the package manufacturer and printer must be called in. He will know what materials are available, what their protective qualities are and how they can be converted and printed. There have been many instances of a package being designed which could not be manufactured on standard equipment and whilst it is generally true that special fittings are available, many containers are made on automatic equipment, whereas fittings may have to be made on hand-operated or semi-automatic machines. In this connection one is more likely to run into difficulty with the internal fittings than with the outer case or carton. Substantial savings in cost can often be achieved by allowing a reliable manufacturer some latitude in the make-up of the container. Particularly is this so with wooden containers, where the variability of the material is such that small variations in thickness of timber, or width of boards, may be of little consequence, but may nevertheless enable the case maker to make economic use of available material.

Lastly, the packaging engineer will want to know how the proposed package will behave in practice. He can either carry out a controlled field trial with a reasonable number of packages sent to a few trusted customers with requests for reports on damage, convenience, sales appeal, etc., or he may decide upon laboratory tests. The former method is time-consuming and failure of the package can prove expensive,

since usually a fairly large number of packages must be employed to obtain a fair cross-section of likely damage. The second method offers the substantial advantages that only a small number of packages is required and tests are carried out in the laboratory under controlled conditions, so that it is possible to know to exactly what hazards each package has been subjected. Also, laboratory tests can be accelerated to some extent so that an answer can be obtained much more quickly than by a field trial.

It is the responsibility of the packaging engineer to consult with his colleagues in the appropriate departments at an early stage in the design of any product, so that he can be in a position to ensure that the necessary packaging material will be on hand when required. This may seem elementary, but it is surprising how often one finds that packaging is left to the last minute, so that when the production line starts rolling no suitable packs are available. The panic conditions of such a situation are not the best for efficient package design!

packaging specifications

Provided that the discussions with the various departments mentioned above have been properly conducted — and packaging is largely a matter of asking the right questions — the packaging department will be in possession of the necessary information to enable them to draw up a specification for the pack. With the many advances being made in packaging materials, the use of specifications becomes not only desirable but essential. Briefly the information available will provide an assessment of the product requirements from the point of view of physical and environmental protection, and from the sales and marketing aspect. The suppliers will have indicated how closely they can can get to the ideal and what tolerances they require.

Specifications must be sufficient to protect the user against over- or under-packing, both of which are wasteful of time and money. It is largely a matter of deciding what is required and what tolerances can be accepted without jeopardising efficiency. A high speed carton packing line will need closer tolerances on dimensions and folding qualities than a hand line. Minor defects in quality can perhaps be overlooked in 5% of the total, whereas a major defect in even ½% might cause the rejection of a whole consignment; that is, quality control of packaging material must be established. The scope of the control system will be determined by the complexity of the specification. Information on tests is readily available from Patra, from trade organisations and from technical publications such as the Packaging Code (B.S.1133) already referred to, from test methods laid down by TAPPI [19] and ASTM [20]. Two examples of suggested specifications, one for a fibreboard container, the other for a wooden case, are given on the next page.

The complete specification will include also details of sampling and inspection procedures, tests where appropriate and drawings, photographs and printer's proofs.

A word of warning on tests might not be out of place here. There is a tendency to employ all sorts of tests on packaging material, many of which are not relevant to the desired properties of a given package. It is always desirable to employ standard tests where they exist and to keep them as simple as possible. Particularly is this so with tests which require special apparatus, for this is frequently expensive.

It would not be right to leave the subject of specifications without reference to two publications which together provide the packaging engineer with much basic information and form the basis of a code of practice. These are B.S.1133 (The Packaging Code) and The General Classification of Merchandise of the Railways Clearing House [33]. Reference has already been made to some of the Sections of B.S.1133, but there are 20 in all dealing with all functional aspects of packaging materials and methods. A complete list is given in Appendix 2. Like all British Standards, the Packaging Code is brought up to date from time to time, and new sections are added. Copies of the various sections are available from the British Standards Institution.

The Railways Clearing House Classification of Merchandise besides giving the regulations relating to the carriage of goods by rail, also includes guidance on the selection of materials for outer containers. The railway authorities base their acceptance of packages for carriage at Company's risk rates on this Classification, supplemented by simulated journey tests carried out in their laboratory and by practical experience.

It will be argued that to draw up specifications along the lines indicated entails a lot of work, but there are numerous advantages to be gained, of which the following warrant special mention :-

1. Increased knowledge of packaging materials, their properties and functions, improved consistency of quality and reduced customer complaints.
2. Standardisation of container sizes and quality, with improvements in operating efficiency by reducing changeover times.
3. The maintenance of quality by concentrating inspection and testing on major issues. Without specifications a gradual drift away from original requirements is inevitable.

Once specifications have been written they should be revised as necessary in the light of performance and development of new techniques.

qualities of a packaging engineer

The packaging engineer, or packaging officer, call him what you will, must be able to reconcile the views of the various production and sales departments, as well as ensuring that the final pack is functionally as near perfect as possible. It will be worthwhile looking at the desirable qualifications for such a person. Firstly, wherever possible responsibility for packaging should be a major part of one person's activities. It is rarely satisfactory to leave it to the

EXAMPLES OF SPECIFICATIONS

Fibreboard Box

Type of board — corrugated or solid style
Dimensions with tolerances
Order of panels
Flute and grain direction
Flaps

Board Quality
- (a) Furnish
- (b) Basis wt and caliper
- (c) Flute — A, B, C, or A/B
- (d) Details of liners
- (e) Details of corrugating medium
- (f) Strength:-
  - (a) Board
  - (b) Finished box
- (g) Moisture resistance
- (h) Chemical properties

Manufacturer's Joint:-

1. Stapled.
- (a) Number of staples
- (b) Gauge and shape of wire
- (c) Rust resistance of wire
- (d) Position of staples

2. Glued
- (a) Type of glue
- (b) Aging characteristics

3. Taped
- (a) Type of tape — paper, fibre
- (b) Size and amount of tape
- (c) Colour and printing
- (d) Quality

Printing
- (a) Text
- (b) Position on Panels
- (c) Size of characters
- (d) Colour
- (e) Ink — rubfastness, waterproofness, lightfastness.

Scale drawing of printing where possible.

Closure
- (a) Gluing — type of glue
- (b) Taping — type, colour and position of tape
- (c) Stapling — number and position of staples.

Workmanship and Tolerances
- (a) Cutting of board
- (b) Creasing of board
- (c) Alignment of joints
- (d) Alignment of tapes, staples, etc.
- (e) Permitted defects, number
- (f) Magnitude allowed

Inspection Procedures
- (a) Sample size
- (b) Method of sampling
- (c) Conditioning of samples
- (d) Tests, with permitted range of results.

Wood Box

Hardwood/Softwood/Plywood (or list permitted species)
Style
Dimensions with tolerances
Sizes of individual members, including minimum width and maximum permitted number of boards per panel.

Battens
- (a) Number
- (b) Size
- (c) Position

Wood Quality
- (a) Maximum permitted knot size and number
- (b) Cross grain and staining
- (c) Moisture content at assembly
- (d) Finish — planed or sawn

Jointing

1. Nails
- (a) Number
- (b) Gauge and length
- (c) Type — plain, coated or threaded
- (d) Position and clinching

2. Screws
- (a) Number
- (b) Gauge and length
- (c) Type of metal, coating, etc.
- (d) Position and predrilling

3. Reinforcements
- (a) Steel straps — number position and gauge
- (b) Hoop iron — number, position and gauge
- (c) Wires — number, position and gauge
- (d) Finish of reinforcements

Marking
- (a) Text
- (b) Position on panels
- (c) Size of lettering
- (d) Colour
- (e) Waterproofness, lightfastness and rubfastness of ink
- (f) Provision for affixing labels

Illustration of marking where possible

Workmanship and Tolerances
- (a) Splitting at nails and Screws
- (b) Overdriving of nails and screws
- (c) Adequacy of clinching
- (d) Rough edges and poor finish
- (e) Alignment of components — spacing between boards

Inspection Procedures
- (a) Sample size
- (b) Method of sampling
- (c) Conditioning of samples
- (d) Tests, with permitted range of results

buyer, transport manager or production engineer to fit it in during his spare time, or to pass it on to one of his assistants if he doesn't have any spare time. It is desirable that the person selected should know something of what goes on in the production and sales departments, so that he can visualise how the packaging operation fits into the cycle of production and marketing. He should know something of the problems of stock control and despatch, especially where he is dealing with a large number of different lines. A well-organised packaging department can do much to avoid bottlenecks in the flow of materials through a factory, whilst a poorly-organised one can lead to colossal waste of labour and even complete chaos. The packaging engineer must therefore be able to organise his staff into an efficient team. He must evaluate the many automatic aids which are on the market today, to determine which are best suited to his own particular problems. If full automation is not economically or functionally possible, there are many other aids, such as power conveyors, staplers, labellers, strapping tools and storage systems which are adaptable for numerous types of pack. He should be familiar with the techniques of work study, so that the whole operation from receipt of packaging materials at the works to despatch of customer's orders can be carried through with the minimum waste of effort and at the minimum cost.

On the design side, the packaging officer must be able to work from drawings to determine the packaging requirements of each product before it is produced. He will frequently be able to suggest modifications which, while not impairing the efficiency of the product or increasing production costs, will enable the packaging costs to be reduced. An example which comes to mind is that of a certain make of refrigerator on which the firm's packaging department asked for extra supports to be provided for the heavy compressor unit. When this was done, at a cost of about one shilling, a saving of over six shillings was made on the packaging cost. The extra supports were quite unnecessary once the product reached its destination where it might only be moved once or twice in its working life, but were essential for the dynamic loads encountered during transit. It must be the responsibility of the packaging department to translate packaging requirements into a specification, which, while allowing the supplier sufficient latitude to make the best use of available materials, nevertheless provides the purchasing department with a basis on which to work. Even when a pack has been approved and is operating well, the packaging officer should always be on the look-out for possible improvements — a slight change in design perhaps, which makes for quicker filling, or a new material giving greater protection at no extra cost. To sum up, perhaps the following qualities lead to the ideal packaging man :-

1. experience in production and marketing;
2. a wide appreciation of the problems and aims of his own company;
3. a knowledge of all available packaging materials, handling equipment and production aids;
4. an ability to plan ahead and maintain a flexible outlook, to evaluate new ideas without being carried away by them;
5. finally, an abnormal amount of tact, imagination and common sense, with an ability to learn from mistakes, whether his own or those made by others.

Such a man will, of course, be easily recognised by his shining halo!

To sum up, the exact way in which the packaging function is fitted into an organisation is a matter which individual companies must decide for themselves. This section has only given a general outline of the packaging department's responsibilities and the requirements of its chief. The importance of the various aspects of packaging, such as protection, stock control, ease of handling and identification, advertisement and costs varies widely from product to product and it is quite impossible to lay down precise rules. The essential thing is that packaging is a co-operative project which cannot be shut off into a watertight compartment of its own. Any packaging operation must be viewed in the light of its effect upon the whole cycle of production and marketing.

Further useful information of the subject of this section is to be found in articles by Major [21], Stought [22] and Cyrol and Borck [23].

packaging for the services

The problems involved in packaging for the Services are not basically different from those encountered in industry, but there are special factors which need to be taken into account in some instances.

The great multiplicity of stores and supplies necessary for the smooth working of the modern Services fall into two parts :-

(1) *Those required for day-to-day use in the United Kingdom or at known stations overseas.*

These stores are subject to the same transit hazards as normal commercial packs, the period of storage is usually short and the climatic conditions can be forecast in advance. For these goods the Services are often prepared to accept the normal trade packs or what is called an Agreed Industry Standard; that is to say, a standard of packaging which has been agreed with the responsible trade Association in the industry concerned. The Agreed Industry Standard may be based on the normal export packing of leading manufacturers or it may be modified in some way by agreement among the three Services and the industry concerned. This lecture is not specially concerned with this class of supplies.

(2) *Those which are intended as supplies in times of emergency and which are required to be packed to the standard known as Full Standard Packaging.*

In general the Services are not able to forecast either the destination or the required storage period of these goods, and it is thus essential that the packs maintain their contents in perfect condition during

transit to any part of the world and during storage under any climatic conditions for an indefinite period.

It is in the packaging of these goods that special factors arise. Firstly, in industry a small amount of transit damage can be tolerated, and is indeed looked upon as normal. It would be hopelessly uneconomic to cater for the worst combination of mechanical and climatic hazards that can possibly occur anywhere in the world.

This is not so in the case of the Services, where a package designer is not entitled to regard damage to even the most minute proportion of goods as tolerable. The consequence of damaged military stores in time of war may well be measured in terms of human life rather than in terms of cash. This lesson was, in fact, learned the hard way during the campaign in Burma and the Far East during the last War, when large quantities of stores and equipment were found to be useless when required owing to inadequate protection having been provided against the adverse climatic conditions prevailing in that theatre of war.

Secondly, the nature of the supplies means that they may constitute a danger to life and limb if not properly packed. Especially is this true of ammunition, where there have been instances of corrosion due to inadequate climatic protection rendering ammunition dangerous to handle and certainly unfit for use.

Thirdly, during the long periods of storage goods may be transported several times from one part of the world to another as the exigencies of the Service demand. Thus not only are the mechanical hazards multiplied, but several widely varying sets of climatic conditions may well be encountered during the life time of a given package.

The Services have tackled these problems by a closely-knit system of specifications which have been agreed on a joint Service basis and are listed in a document entitled DEF 1234 "General Requirements for Packaging Supplies for the Services", to which reference has already been made. Having regard to the multiplicity of stores required, it was essential in drawing up any packaging scheme to look for the fundamental principles underlying good packaging, rather than to attempt the classification of packs on a piece-meal basis. Even so, there are a number of criteria which could have been adopted. For example, packs might have been classified according to the degree of mechanical protection which they afford to their contents, or the supplies themselves could be classified by their fragility and susceptibility to mechanical damage. In practice it has been found most convenient to classify packs by the degree of protection which they afford against corrosion and four major types are recognised.

(1) *The non-waterproof package,* designated *Method I* if a temporary corrosion protective is applied, and *Method O* if no temporary protective is used. The use of this method is confined to those stores which do not corrode or which are so robust that some measure of corrosion can be tolerated, for example, railway lines, pick axes, crowbars and similar items.

(2) *The waterproof package Method IC.* This package incorporates a continuous barrier which is impervious to *water.* If protection against water vapour is required it is usually provided by means of a thick film temporary protective or strippable coating.

(3) *The water vapour-proof package Method IA.* Packages of this type involve the use of either an impervious hermetically sealed container or a sealed *water vapour-proof* barrier having a transmission rate not more than 1 gm. per sq. metre/24 hours at 100°F and 90% R.H. Water vapour-proof packages are normally only used for those items of equipment for which an oil or thin film temporary corrosion protective are the only suitable preventive treatments. Examples are certain precision measuring instruments and various tropic-proofed electrical assemblies and some items of aircraft and radar equipment.

(4) *The desiccated package. Method II.* This pack resembles the *Method IA* pack except that a desiccant which is usually, but not invariably, silica gel is included within the water vapour proof-barrier with the object of maintaining the relative humidity within the package below 50%. The amount of desiccant used is calculated by the formula which is set out in Appendix 1 of this lecture, and provision is made for redesiccation after the lapse of various periods of time calculated according to the climatic conditions prevailing in the storage area.

Method II packs will normally be used for electronic and electrical equipment, motors and generators, cameras and optical instruments and items of medical stores — in fact, any items or complex assemblies which are unsuitable for protection with temporary corrosion preventives.

It is a Services' rule that all supplies must be obtained by competitive tender, and when calling for tenders the Services' packaging branches will normally call up packaging materials according to a series of specifications which will cover outer containers, furniture, waterproof barriers, corrosion preventives and, where appropriate, desiccants. It is often claimed that these specifications are far too rigid and that in consequence military packaging is too complicated and too expensive, but it must be remembered that they are based upon many years' experience in many theatres of war, and that they are at best a compromise between what is ideally required and what it is practically possible for the industry to supply. Having regard to the possible consequences of failure conformity with specification is absolutely essential, and the Services Inspectorate branches will normally examine consignments for conformity with specification and will carry out tests on packaging materials as well as on the packaged items.

In addition to specifications for materials, DEF 1234 also includes a sechedule of tests which all Full Standard packages must be capable of withstanding. The object of these tests is to ensure that the mechanical strength of the packages is sufficient to enable them to withstand the hazards of transport to which they are likely to be subjected. The

mechanical tests include drops together with periods of vibration and bumping, and are designed to show up fairly quickly any basic mechanical weakness in the design of the pack. The sequence also includes climatic tests such as exposure to desert conditions, tropical conditions and cycling conditions of temperature and humidity which can be expected to show up any instances where the wrong type of corrosion preventive has been used. In addition to the tests, the Services occasionally carry out fairly large scale field trials on various types of package, incorporating any new materials or ideas which may appear from laboratory tests to be worthy of further investigation, and they have in addition a number of locations, such as Port Harcourt and Lagos, where packages can be exposed to very severe climatic conditions for long periods of time.

It must not be thought that because Services packaging is governed by specification that it is rigid. All specifications are kept continuously under review and are brought into line with modern requirements and production techniques when it can be shown that modifications can be safely made without loss of safely and efficiency.

trends and developments

materials handling

Much of the basic economics of packaging rests on an accurate assessment of the journey hazards, from which it follows that anything which contributes to a reduction in such hazards and an improvement in handling will lead to a reduction in packaging costs. It is, perhaps, a little curious that mankind has devoted a great deal of attention to moving himself and his goods great distances by building a well-integrated transport system and has also made a rational study of the science of moving things which are within arm's length, through time and motion study, but has until recently neglected the gap between. Even now, problems of materials handling over short distances do not always receive the attention they deserve and it is not uncommon to see the most modern production systems geared to materials handling techniques, the economics of which have never been investigated.

Within the factory there are many aids, such as moving belts and roller conveyors, which can be used to make handling easier and industry has not been slow to make use of them. Many, however, are not sufficiently versatile and mobile to be of much use to the transport authorities who, of course, are faced with a much greater diversity of packages to move than any single manufacturer. Their thoughts have turned in other directions.

It has already been pointed out that within broad limits heavy packages receive better handling than lighter ones, and it would seem to be a reasonable extension of this that if small packages could be built up into some kind of "unit load", which could be handled mechanically rather than manually, they would sustain less damage in transit. This line of thought has undoubtedly been prominent in the minds of people concerned with cargo handling during the post-War years and in spite of the fact that acceptance of mechanical aids has been pitifully slow, much progress has been made in the use of fork-lift trucks, pallets and "containers", using this latter word for the moment in its materials handling rather than its packaging sense.

The employment of unit loads brings problems in its train for both transport authorities and manufacturers. For example, not all trucks and ships are constructed to accommodate pallets. There are virtually no straight sides in ship's holds. Pallets must be returned empty and the volume of traffic must be such as to pay for the purchase of fork-lift trucks and the necessary maintenance facilities. Undoubtedly one of the biggest problems facing users and transporters alike is that of standardisation of pallet sizes, for it is certain that if pallets are ever to be fully utilised, some standardisation of sizes is essential, otherwise chaos will result.

It is axiomatic in package design that the primary consideration must be the protection of the packaged article. If this is not achieved satisfactorily, the whole operation becomes pointless. But it is recognised that there are many instances where slight changes of dimensions can be made without any reduction in the degree of protection provided, and where any slight increase in cost can be more than offset by a saving in handling and transport costs. With this consideration in mind the problem of pallet sizes has been considered both nationally and internationally. A British Standard, B.S.2629 "Pallets for Materials Handling", has been published which lists six sizes of pallet, some of which have already been agreed upon by both sides of industry. These sizes are :-

1. 40 in. × 60 in.
2. 40 in. × 48 in.
3. 40 in. × 40 in.
4. 36 in. × 40 in.
5. 32 in. × 48 in.
6. 32 in. × 40 in.

Numbers 2, 5 and 6 in this list have also been agreed internationally by a committee of the International Standards Organisation on which many European countries were represented. Discussions on these sizes are still going on and it may well be that in the near future the British sizes will be revised and more sizes added to the International list.

The standards also include specifications for materials and performance tests. If such standards could be generally adopted, enormous benefits would accrue to users and transporters alike and it might be possible eventually to operate a "pallet pool", thus obviating the problem of returning empty pallets. Needless to say, there are many problems to solve before such a state of affairs can be brought about.

the modulus system

Inseparably linked with the problem of standard pallets is that of standard packages. Everyone has their own ideas of what is best for their own particular product, and it is by no means a simple matter

to design a pack which would ensure adequate protection for the packaged article and yet fit exactly on to a given pallet without wasting either space or material. Nevertheless, there are advantages in standardisation and at least one country, Australia, has gone some way towards achieving it. The Materials Handling Branch of the Australian Department of National Development has suggested a system based on the "Module of Movement", namely the pallet [31]. One essential pre-requisite to the successful operation of the system is already operative in Australia, that is, there is one size of non-captive pallet, 46 in. $\times$ 46 in. The system has been examined in other countries, notably the U.S.A. and the European Packaging Federation has set up a working party to examine and report on the whole question of Modular Packaging. It is not suggested that the Australian scheme is the panacea of all materials handling ills, nor is it intended as such. Obviously there are exceptions, but it is worthy of a little consideration. Briefly, it provides a system of mathematically related package sizes aimed at reducing the number of transit containers and making economic use of the pallet. The 46 in. module can be divided by any convenient factor from 1 - 8 except 7 to obtain one of the dimensions of the package. The other dimensions can be obtained in a similar way. Thus a number of plan arrangements are obtained which can be oriented on the pallet in many different ways, whilst still fully utilising pallet space.

A related problem frequently encountered in packaging is that in which very many different sizes of outer container are required to accommodate the whole range of a company's products. Very often some sizes are only required in small numbers and at irregular intervals, but it is nevertheless important to have them on hand when required. Under such circumstances packaging material storage and stock control can become a major operation. To overcome this difficulty, the idea of Modular Panel Packaging has been proposed. The idea is simply that outer containers can be built up from stock size panels. As a small number of container dimensions can be built into many types of pallet load, so a small number of panels can be used to build a large number of containers. The advantages are savings in materials and labour, reduced storage space and rapid box assembly when needed. The idea has been developed amongst aircraft manufacturers and other diverse interests in the U.S.A. and has progressed to the point at which a Military Specification (MIL.-B.-26241 Demountable Box Specification) has been published. An excellent account with charts for determining the number of container sizes which can be made from a given range of panel sizes is given in a progress report in an American journal, Material Handling Engineering [32].

A good deal of study may be required before the best panel sizes for a particular company's system can be selected. If a large number of box sizes is required the mathematics becomes rather involved, but a number of charts have now been worked out for various ranges of container size.

new materials

Undoubtedly the most noticeable trend in post-War years has been the change from wooden containers to those made from fibreboard. In no field has the change been more marked than in that of engineering products. Equipment which a few years ago would have been packed in heavy wooden crates is now forwarded in light fibreboard boxes. Whereas the weight limit for fibreboard a few years ago was about one cwt., it is now quite usual for refrigerators and similar articles weighing 4 cwt. - 5 cwt. to be packed, and there have been numerous instances of assemblies weighing a ton or more being packed in fibreboard cases. One of the major problems is the adverse effect of moisture on fibreboard, but research is providing the packaging engineer with moisture-proof and moisture-resistant grades at competitive prices.

Other developments have been in the field of cushioning materials, where foamed and cellular rubbers and plastics have become available. Improvements in manufacturing techniques have enabled the properties of these materials to be carefully controlled during manufacture. Recently news has come of a foamed material which can be built up into the shape required during the actual packaging operation [34]. It is a co-polymer of polyurethanes and polyesters, is claimed to be heat sealable and can be sewn and glued. It will withstand the effects of boiling water and sea water and is resistant to chemical attack. If the claims made should prove to be justified and it can be made reasonably cheap, then there is no doubt that there is a place for it in packaging.

marketing trends

With the return of days of plenty after a decade of shortages, it was perhaps inevitable that there should be great changes in marketing techniques. More emphasis is laid on sales appeal and those packaging materials which lend themselves to adornment have gained ground at the expense of others. Engineers have not felt the impact of new sales techniques to the same extent as the food manufacturers, but even in this field there is evidence that the pack is required at least to help sell what it protects as well as protect what it sells. The success of the fitted display carton used by the manufacturers of the "do-it-yourself" range of power tools shows how attractive display can be combined with functional efficiency. Moulded containers made from plastic sheet are now cheap enough to be used for many low priced articles and the introduction of efficient high speed batch counting systems enables many kinds of small articles to be sold in packaged form instead of loose.

Market research techniques are only now beginning to be applied to package design problems in this country, but enough has been done to indicate that in the whole field of consumer goods attractive packaging can be a powerful sales aid. Apart from protection of the product the retailer handling consumer goods will want a pack which stacks well on his shelves, makes a good display, identifies its con-

tents and tells the customer what he needs to know about them. Evidence is accumulating that modern advertising, especially television, serves to create a brand image in the customers' mind and when a product is displayed in its pack, the image formed is that of the complete entity. A pleasing design is therefore essential.

package testing

Reference has already been made to the use of tests as a means of estimating the efficiency of a package in practice without going to the trouble and expense of field trails. In this section some of the apparatus used to carry out these tests will be described and illustrated. The aim in general is to reproduce the hazards of transport in the laboratory and to make use of accelerated tests where they can be shown to be justified. It is possible to reproduce both mechanical and climatic hazards quite accurately, provided that sufficient is known about their intensity in practice. In this way laboratory journey sequences can be built up.

mechanical tests

There are five main types of apparatus that can be used to simulate mechanical hazards :-

1. *Drum test*

This test was the first laboratory test developed. It arises as the direct successor to the method of testing by rolling a package down a flight of stairs. Essentially, it produces the effect of making the stairs revolve around the package. The package is placed in an hexagonal drum made to revolve in such a way that the package is caught up on baffles and guides and is subjected to six falls during one complete revolution of the drum. The baffles are so arranged that the package will fall in various positions on to an edge, a corner or a face. There are two sizes of drum in general use, one 7 ft. in diameter (available at PATRA) and one 14 ft. in diameter. The 14 ft. drum naturally gives somewhat more severe treatment than the 7 ft. drum.

The great disadvantage of this test lies in the fact that the sequence of falls is not reproducible and is, moreover, dependent on the size and shape of the outer container. The test is, however, simple and convenient and can give useful information about the relative strength of various types of containers. Patra's 7 ft. drum is shown in Fig. 9.

2. *Drop test*

The drop test is capable of giving a good deal of useful information on the strength and protective qualities of both the container and the package. It consists of a means of dropping the package in a particular position from a selected height. The simpler type of tester consists of a pulley system for adjusting the height of the package, which is held in position by slings and a quick release mechanism to allow the fall to occur. Some packages are very difficult to sling, however (for example, drums, barrels and sacks) and for these it is better to use a trapdoor

Fig. 9. 7 ft. revolving drum.

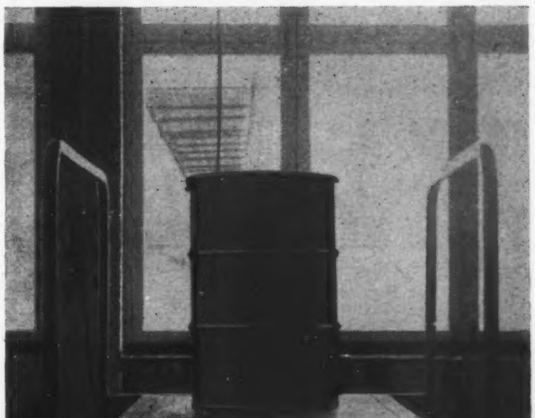


Fig. 10 Table Drop Tester.

Fig. 11. Inclined Plane.

type of tester (Fig. 10) in which the package stands or is held in position on a trapdoor that is suddenly opened to allow the package to fall on to the floor.

3. *Inclined plane test*

The original object of this test was to reproduce the type of shock encountered during shunting on railways. The apparatus consists of a truck inclined to the horizontal at an angle of 10°, on which runs a "dolly". At the bottom of the track a heavy wooden bumper is braced into position at rightangles

Fig. 12. Compression Tester.

to it. The package to be tested is placed on the "dolly" so that its leading edge, face or corner, is level with the leading edge of the "dolly". The "dolly" is then drawn up the track to the distance required and allowed to run down so that the package impacts the bumper. The speed at impact can be varied up to about 8 m.p.h., according to the length of the run. It is a particularly useful test for packages when fragile articles such as bottles are separated one from another by some simple form of cushioning. Fig. 11 shows a package at the start of its run.

4. *Compression test*

This test subjects a container to crushing forces similar to those encountered when packages are stacked in warehouses or in transit. From the results of the tests, an estimation of the safe stacking height for any particular container can be made. It consists of two parallel platens that can be driven together. A dial gauge records the load on the package at any particular instant and the apparatus is fitted with a chart recorder that automatically records the load against the degree of compression. Fig. 12 shows a test on a fibreboard container.

As well as being used for purposes of estimating safe stacking heights, this type of test can be used particularly with wooden and other semi-rigid types of container to assess the distortion of the container under a known rate of loading, thus obtaining quite useful data on the relative behaviour of various types of construction.

5. *Vibration test*

Packages that have to travel long distances by road or rail are subjected to a considerable degree of vibration during transport. Vibration tables have been designed to reproduce this type of effect and to allow a measure of the efficiency of any package against these hazards to be estimated. The tables usually consist of a platform to which a vibratory movement is transferred by means of a cam system or eccentric rods. With the more elaborate models, both the amplitude and the frequency of vibration may be controlled. In the test, the package is placed on the table and the frequency adjusted from the slower speeds upwards until a level of testing has been reached at which the package is just leaving the table once in each cycle. It is a very useful test, particularly as it allows the investigation of vibration on stacks of containers such as would be assembled in rail cars and in road transport.

Two tables are in use at Patra. The LAB machine illustrated in Fig. 13 has an amplitude of 1 in. and frequency variable between 2 - 6 cycles per second. The other table has an amplitude adjustable up to 0.25 in. and a frequency variable between 1 - 15 cycles per second.

In addition to these two tables there is also a Bump Table, illustrated in Fig. 14. This table is used for testing packages intended for H.M. Armed Forces and its design and use is covered by Government Specification. In practice the package is

secured to the table and ballast is added under the table until the total weight is 500 lb. The whole table then vibrates up and down and impacts upon a rubber anvil so that the pack is subjected to a deceleration which is normally 40g. at an amplitude of 1 in. and a frequency of 3 bumps per second.

By a suitable combination of these tests a sequence can be built up to simulate the hazards of any distribution system.

climatic tests

When it is necessary to include climatic tests in a test sequence as, for example, when packages are intended for export, this can be done by the use of a shower test or by exposing the package in rooms controlled at the appropriate conditions of temperature and relative humidity. Tropical storage tests are usually carried out at 38°C and 90% R.H. and dry heat tests at 55 or 60°C with as low a humidity as possible. Cyclic conditions are also obtainable to simulate diurnal changes. Patra has five rooms available covering tropical desert and cold conditions. In addition small packages can be exposed in cabinets (Fig. 15) in which any desired combination of temperature and relative humidity can be obtained.

By judicious use of this equipment the effect of various climatic conditions on packages can be tested and the efficiency of corrosion prevention treatments can be observed.

The usefulness of tests depends to a large extent upon the accuracy of the assessment of the transit hazards and much of Patra's research on the packaging side has been devoted to the collection of appropriate data. A good deal of experience is necessary in devising test sequences and interpreting results. In some instances it may be possible to compare the efficiency of an experimental package with that of one already in use. Experience gained with the latter can provide a check on the accuracy of the test sequence. Where a new product is concerned or where one wishes to reduce the protection provided to an established line in order to lower costs, then an accurate assessment of the hazards to be expected is vital.

There is now sufficient evidence to show that these tests, properly used, do give a reliable guide to what happens in practice. There are now a number of standards for packaging materials in various countries which include performance tests of this type, particularly drop and compression tests. There can be no doubt that by intelligent use of package tests linked to tests on base materials it is possible in many instances to pack to specification and have a good idea of the risks one is running.

conclusion

It is a condition of the George Bray Memorial Lecture that it shall be on a subject not traditionally associated with engineering. Whether or not this lecture fulfils the condition depends upon how long it takes to establish a tradition, for it is quite apparent that packaging is very closely connected with engineering. The Oxford Dictionary defines an engineer as one who contrives, designs or invents. The

Fig. 13. L.A.B. Vibration Tester.

chances are that sooner or later he will want to sell his product, which will immediately bring him into contact with packaging problems. If this Paper does something towards helping him to tackle his problems logically, it will have achieved its object. The reader may perhaps complain that there is little which bears on his particular problem, but for that he and his colleagues must bear part of the blame — their products are so many and varied, but perhaps enough has been said to suggest that packaging is

Fig. 14. Bump Table.

emerging from the status of a craft and becoming a science whose problems are amenable to scientific treatment.

It is fashionable for authors of Papers of this type to attempt to look into the future. Packaging is developing very rapidly indeed and scarcely a day passes without new material or piece of machinery being put on to the market with a fanfare of trumpets. But perhaps, during the next few years, most progress will come from new techniques of materials handling and from expansion of traditional materials into fresh fields than from the development of new packaging materials. Increased mechanisation, leading to better handling, will enable costs to be cut while changes in marketing techniques will make new demands on packaging. Improved knowledge of materials and methods will lead to better package performance and improved presentation. Such progress, though perhaps not spectacular, is nevertheless essential if packaging is to play its full part in economic expansion.

Finally, on a personal note, the Author would like to thank the Institution for presenting him with the opportunity of compiling a Paper which has been most interesting to write and he hopes, to read.

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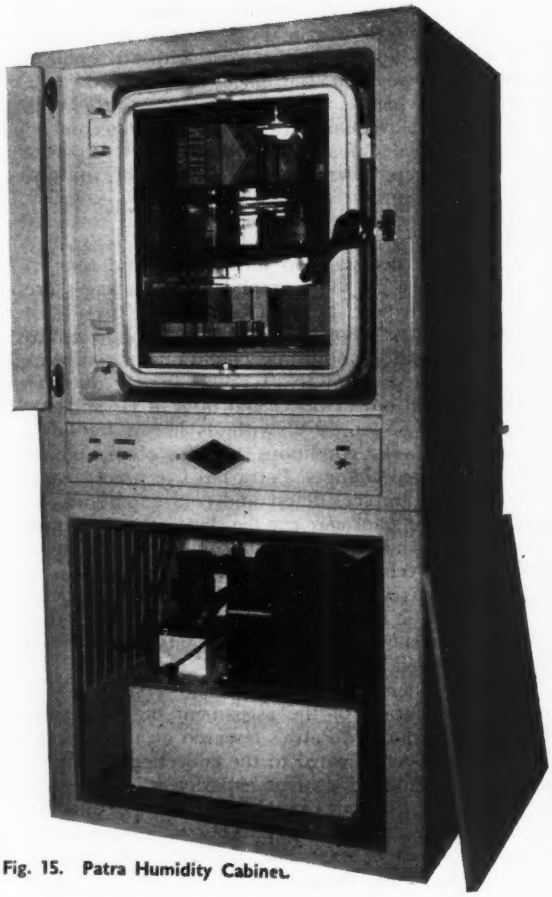


Fig. 15. Patra Humidity Cabinet.

REFERENCES

1. *DEF-1234*. "General Requirements for Packaging Supplies for the Services." H.M.S.O.
2. *Brit. Stan.* 3130 "Glossary of Packaging Terms." British Standards Institution.
3. Ports of the World. 4th Edition. Insurance Co. of North America and Philadelphia Fire and Marine Insurance Co.
4. Patra Packaging Laboratory Report No. 4. Confidential to Members of Patra.
5. Patra Packaging Laboratory Report No. 5. Confidential to Members of Patra.
6. *Motor*. October, 1959.
7. Schuler, S. C. *Journal Royal Aeronautical Society*. Vol. 61, 1957, page 335
8. Miller, D. G. *Packag. Rev.* Vol. 19, No. 155, July - August, 1959, page 104.
9. *Materials Handling Engineering*. Vol. 14, No. 10, July, 1959, page 70.
10. Brynhildsen, H. O. and Dagel, Y. *Svensk PappTidn.* Vol. 62, February, 1959. page 77.
11. "Corrosion in Packaging" published by Patra and Institute of Packaging.
12. Paine, F. A. and Watkinson, D. *Proceed. Corr. Conv.* published by Corrosion Technology, London, 1959.
13. Brit. Stan. 1133. Sect. 6. "The Packaging Code.
14. Stroud, E. G. and Vernon, W. H. J. *Jour. Appl, Chem.* Vol. 2, 1952, page 178.
15. Evans, E, Ll. and Stroud, E. G. *Chem.* & *Ind.* 1957, pages 242 - 248.
16. Rance, V. E. and Cole, H. G. "Corrosion of Metals by Vapours from Organic Materials." S and T Memo No. 21/57. Ministry of Supply.
17. Ibid. page 23.
18. *Brit. Packer.* Vol. 21, No. 6, June, 1959, page 338.
19. Testing Methods and Recommended Practices. TAPPI.
20. ASTM Standards on Paper and Paper Products.
21. Major, B. F. *Pack. Engng.* Vol. 4, No. 6, June, 1959, page 33.

22. Stought, K. N. Ibid. Vol. 3, No. 2, February, 1958, page 37.
23. Cyrol, E. A. and Borck, R. L. *Mill and Fact.* Vol. 62, No. 4, April, 1958, page 124.
24. Plaskett, C. A. *Bull. No. 171* U.S. Department of Agriculture.
25. Stern, W. Package Engineers Handbook. Published by Board Products Publishing Co., Chicago.
26. *Brit. Stan.* 2540. " Silica Gel for use as a Desiccant for Packages."
27. *Brit. Stan.* 2541. " Activated Alumina for use as a Desiccant for Packages."
28. Mindlin, R. D. " Dynamics of Package Cushioning." Bell Telephone Company Monograph.
29. Brown, K. " Package Design Engineering." John Wiley & Sons Inc., New York.
30. *Brit. Stan.* 2629. " Pallets for Materials Handling."
31. *Packag. Rev.* Vol. 79, No. 151, March, 1959, page 46.
32. *Materials Handling Engineering.* Vol. 14, No. 6, March, 1959, page 98.
33. General Classification of Merchandise. Railways Clearing House. British Transport Commission.
34. *Emballages.* Vol. 28, No. 173, March - April, 1958, page 21.

APPENDIX 1

Calculation of Quantity of Desiccant Required

basic desiccant

The basic desiccant is defined as one which will absorb 27% of its dry weight of moisture when placed in an atmosphere maintained at 25°C and 50% Relative Humidity. The following calculation applies to the basic desiccant. When using commercial grades their absorption capacity must be determined and the appropriate correction factor applied.

Let
- W = Weight in pounds of basic desiccant
- A = Area in square feet of water-vapour barrier
- D = Weight in pounds of hygroscopic material, e.g., cushioning, cartons, inside the barrier
- M = Storage life required in months
- R = Water-vapour transmission rate in grams per square metre per 24 hours at 38°C and 90% Relative Humidity
- V = Volume in cubic feet of air inside the barrier

Then $W = \frac{ARM}{60} + \frac{D}{2}$ for storage at tropical conditions

$W = \frac{ARM}{360} + \frac{D}{2}$ for storage at temperate conditions

$W = \frac{V}{100} + \frac{D}{2}$ for packages with a completely waterproof barrier, eg., hermetically sealed tins.

The approximations made in driving these formulae are sufficiently accurate for practical purposes.

APPENDIX 2

B.S.1133 The Packaging Code

There are now 20 sections of the Packaging Code covering various aspects of packaging materials and equipment. A complete list of sections is as follows :-

Section
1. Choice of containers and method of packaging.
2. Storage of packaging materials.
3. Addressing, marking and identification.
4. Mechanical aids in package handling.
5. Protection against spoilage by micro-organisms, insects, mites and termites.
6. Temporary prevention of corrosion of metal surfaces during transportation and storage.
7. Paper and board wrappers, bags and containers, including films, foils and laminates.
8. Wooden containers.
9. Textile bags, sacks and wrappings.
10. Metal containers.
11. Packaging felt.
12. Cushioning materials and suspension packing.
13. Twines and cords for packaging.
14. Adhesive closing and sealing tapes.
15. Tensional steel strapping.
16. Adhesives for packaging.
17. Wicker and veneer baskets.
18. Glass containers.
19. Use of desiccants in packaging.
20. Packaging for Air Freight.

Copies of the various sections, which are revised from time to time, can be obtained from The British Standards Institution, 2 Park Street, London, W.1.

REPORT AND DISCUSSION

THE President of the Institution (Mr. G. Ronald Pryor), who was in the Chair, in opening the meeting said he was glad to welcome such a large audience. The George Bray Memorial Lecture had been instituted in 1952 when George Bray & Co. Ltd., of Leeds, donated a sum of money to enable a series of lectures to be given in memory of the late Colonel Bray, who had been a very active member of the Institution and at one time President of the Yorkshire Section, as it then was. It was part of the terms of reference that the lectures should be on a subject not traditionally connected with engineering in the narrow sense — in other words, not strictly connected with metal cutting, with which the Institution largely concerned itself at that time.

Lectures had been given on plate glass, synthetic fibres, pride in workmanship, operational research, the fabrication of plastics and the food industry. It was the Institution's custom to invite as Authors only men who were distinguished and had a reputation in their field. The present Paper was an outstanding contribution to the Institution's proceedings. The Institution felt that in inviting Authors to present these Papers it was doing them an honour; and, in return, it was equally felt a great honour when they

Mr. C. H. Bulmer (right) receives from the President of the Institution, Mr. G. Ronald Pryor, a silver rosebowl as a memento of the occasion. The presentation was made in the Grand Council Chamber of the Federation of British Industries, Tothill Street, London, where the Lecture was delivered.

accepted. The Institution liked to mark the occasion by a small presentation which it was hoped would always remind the Author of a happy evening. Accordingly, Mr. Pryor had pleasure in presenting Mr. Bulmer with a silver rose bowl.

Mr. Bulmer, accepting the gift, said:

"I assure you all that I am very deeply honoured at being asked to give this Paper and I am even more honoured by this very impressive attendance. I see among the audience quite a number of old friends, far more than I had expected, and I hope that as a result of the evening I shall make some new friends.

"You will be pleased to hear that I do not intend to read the Paper. In fact, I do not intend to say very much at all. The evening is yours. I will make a few remarks to introduce the Paper and show some films, some of them taken with a high-speed camera which we have at P.A.T.R.A. and one, I am afraid, by way of being a 'commercial'! Afterwards I will take the opportunity to tell you something about P.A.T.R.A. and what we are.

"When the Chairman of the Institution's Papers Committee invited me to give the Lecture, he asked me whether I would provide him with a brief synopsis of what I intended to say, so that he could report to his Committee and make sure that it was suitable. If Mr. Cooke still has that synopsis, I ask him here and now to accept my apologies for not having followed it! To that extent, perhaps, I am here under false pretences.

"I set off with the idea of trying to make some sort of a classification of engineering products and a classification of packaging materials, dividing them up into watertight compartments dealing with the requirements of the one and the properties of the others. But I found that you gentlemen, in your various spheres of life, are far too energetic; your products defy classification. It seems to me that you produce virtually anything and everything and that to meet your packaging needs requires the whole range of the packaging industry's resources.

"What I had to do, therefore, was to diverge a little from my plan. I decided that I would look for the principles involved in packaging rather than burden you with a list of facts and figures which, after all, you can get very much more easily by reading the literature and without having to listen to me.

"The result is a Paper which I feel will probably do very little to solve individual problems. If anyone reads the Paper in the hope that it will tell him how

to pack his products, I am afraid that he will be disappointed. On the other hand, if he is willing to bring thought to bear and expects to find explained in the Paper the considerations which should influence his choice of package, then I venture to hope that he will find something to guide him.

" There is a great deal more to packaging than just putting things into a box, and if I succeed in making people think a little about it, I shall have achieved my objective.

" The package manufacturing industry is very diverse, for it has had to cater for the needs of many other industries. It has attempted to meet the needs of all and, I think, has pretty well succeeded. The situation in packaging today is that, with the range of materials available, you can virtually pack what you like in anything you like, provided that you are prepared to pay the necessary price. It is by thinking about principles that you will be able to get that price down and to take the best advantage of the range of materials which are available, remembering that packaging is not an industry in itself but a function — a function of other industries."

Mr. Bulmer then presented the Paper which appears on pages 497 - 521, after which the meeting was declared open for discussion.

Mr. W. T. Stewart (*Senior Inspector, Packaging Division, E.I.D., Ministry of Aviation*) opening the discussion said that he was very grateful to have the opportunity of being present to listen to Mr. Bulmer and to see his films. He would take the opportunity of starting the discussion at the point at which he suggested packaging should first be considered — on the drawing board of the equipment or component to be protected. Designers, in drafting, should know the destination of the articles which they were to design and should know that these articles would need to be packaged, even if the packaging amounted only to the fastening on of a label. The packaging engineer of a concern or a representative of some packaging authority should be consulted at the drawing board stage and later at the prototype stage of the equipment. From his specialised knowledge he might suggest minor modifications which could take place at this stage. For example, they could considerably simplify the method of holding the component within the container, or they might increase the robustness of the equipment and thereby reduce the amount of cushioning which would be required, or they could facilitate the application of protectives and their ultimate removal.

This kind of consultation was most rewarding and it was hoped might prevent the production of those horrible equipments which often were impossible to raise from the floor, let alone to protect from those hazards which Mr. Bulmer had already described.

At the prototype stage it might well be worth considering whether environmental testing of both the equipment and the package was warranted. Many organisations, including packaging firms, had equipped themselves for such testing and the results obtained would assist the packaging designer as well as the equipment designer to improve their designs, by, for example, the assessment of the fragility of the component.

Most important, the package design would then be ready and would not have to wait until the last possible moment before it could be sent on its journey.

During production, packaging should never be forgotten. For example, articles, as they came off the line, were often stored where they were contaminated with cutting fluid, swarf, the muck and the oil which was found in a shop. They might be left there for weeks, and by the time the protective coating was applied, it was applied over corrosion which might not be apparent until some time later.

It could not be sufficiently emphasised, therefore, that adequate cleaning and thorough drying should be carried out as part of the production process. In this way, the packaging of articles on which corrosion had already commenced could be avoided.

Those precautions should apply whether the article was to be delivered immediately or had to be temporarily stored awaiting assembly. During assembly care should also be taken to avoid further contamination, for example, from human skin, which was a most difficult contamination to remove.

The conditions under which the packaging was carried out should be carefully watched. DEF-1234, " General Requirements for Packaging Supplies for the Services ", which was mentioned in the Paper, could be obtained from Her Majesty's Stationery Office. It described the minimum conditions necessary when supplies to the Services were to be packed.

Mr. Stewart then referred to the other end — the customer receiving the package. It was to be hoped that the utmost care was taken to ensure that the goods arrived in perfect condition and that they were a credit to the skill and workmanship for which Britain was noted. It was hoped that the package would be attractive because it was sound in concept and was designed alongside the component design and not rushed off at the last minute.

If the goods arrived in a damaged condition, it was of no interest to the customer that the packaging was bad. He was only interested in the fact that the articles which he had bought were of no use to him. He would simply go elsewhere to place his orders.

In the U.K. which was so largely dependent on overseas trade, such failures could not be afforded. It was stated in the Paper that the cost of packaging ran into hundreds of millions of pounds annually. Mr. Stewart did not think that that figure took account of the irreparable loss of good will. It was therefore surprising that so little attention was paid by our education authorities to the subject of packaging. He believed that it should be included in the syllabus of the National Certificate and City and Guilds Certificates and Diplomas, etc., so that everyone who was engaged in the production of engineering components was fully aware of the need for sound and efficient packaging.

At the reception preceding the George Bray Memorial Lecture (from left to right): Mr. W. F. S. Woodford Institution Secretary; Mr. G. Ronald Pryor, President of the Institution; Mr. H. W. Bowen, O.B.E., Immediate Past Chairman of Council; and Mr. A. L. Stuchbery, Vice-Chairman of Council.

Mr. A. C. Wilson said he would like Mr. Bulmer to say a few words about the type of work which P.A.T.R.A. was asked to do. From what Mr Stewart had said, and from the films, it seemed that the products mainly being considered were the "many off". Either thousands would be made or a product would be made on a production line basis. Presumably the queries received at P.A.T.R.A. were against that background.

Mr. Bulmer replied that the majority of the work done at P.A.T.R.A. was for equipment designed to go into industry or civilian use, rather than packaging for the Services. There were facilities at P.A.T.R.A. for the latter type of work, and it was increasing. They had a weight limitation in that they did not test anything over half-a-ton.

They did not receive many jobs which were one- or two-off. Most of those were dealt with by packaging contractors on an individual design basis rather than by the firms producing the equipment. They had the production facilities and they were specialists. P.A.T.R.A. could advise on such things but seldom did.

The enquiries received at P.A.T.R.A. relating to engineering products tended to fall into two groups. There were those firms which had produced a new product or wished to exploit new markets. Perhaps they had no experience in those markets. They might want P.A.T.R.A. to design a package, to test prototypes or to adapt an existing pack.

The other type of enquiry arose where a firm had a package which was perfectly satisfactory but too expensive. They have perhaps been using it for years and feel that they have done well in that there have been no damage claims. But they suddenly awake to the fact that packaging is costing them far too much and look for ways of producing a cheaper pack. The job of P.A.T.R.A. was to evaluate any modifications.

Mr. A. R. Plant (*English Electric Aviation Ltd., Guided Weapons Division*) said he wished to ask a two-part question which arose out of something which had happened in his industry and, he believed, in others. Last year they had had trouble with corrosion with cadmium plate stored in cases. The cases had been stored in very humid conditions. Investigations suggested that acid vapours arising in the humid conditions had caused the corrosion.

Was there any method of preventing this corrosion of an assembly? It might be an electronic assembly, in which there were aluminium, rubber-covered wires and solder, as well as the cadmium plated components. It was not possible to apply temporary protective coatings to the cadmium because of coming into contact with the rubber.

Secondly, was any standard code laid down for the correct ventilation of cases in a store area where there was no movement of air? He had searched DEF-1234 and BS 1133, and various other publications, without finding a directive.

Mr. Bulmer, in reply, said that there was no such standard code, a fact which he regretted. The question of ventilation and the maintenance of ideal conditions had arisen before, but nothing was laid down as to what should be done. He liked to think that where paper and board were used, at any rate, they would not be stored in conditions of high humidity. P.A.T.R.A. recommended about 65% R.H. and 68°F. Those were the ideal conditions, and everybody concerned must do the best they could to approach them. No standard was laid down. He knew of temperature records in stores rising to 160°F and in one case 180°F. This was one of the hazards which had to be accepted.

There was always one answer to the problem of corrosion in respect of an expensive item — the desiccated pack. If equipment was packed inside a sealed water vapour-proof barrier, having a low permeability — which meant a permeability less than 1 g./sq. metre/24 hrs. at a temperature of 100°F and relative humidity of 90% — it should be safe from corrosion if a desiccated pack was used.

P.A.T.R.A. had received many complaints about corrosion of cadmium and aluminium. It frequently came back to the question of unsuitable wood being used. Chestnut seemed to be especially bad. The Forest Products Research Laboratory at Princes Risborough and the National Chemical Laboratory had issued some publications on the acid vapours given off by wood. The Paper contained a reference to a comprehensive survey carried out at the Ministry of Supply by Rance and Cole on "Corrosion of Metals by Vapours from Organic Materials".

Mr. J. A. W. Fransham (*Packaging Design and Development Department, Rolls-Royce Ltd.*) said he understood that one of the problems of cadmium plate corrosion was associated with copper naphthenate in the wood. His firm had recently changed to sodium pentachlorphenol. Did the Author agree?

Mr. Bulmer agreed that there had been instances in which copper naphthenate had been alleged to cause corrosion. They had never carried out any tests. They had examined instances of corrosion of metal which had been packed in contact with copper naphthenate and had been able to reproduce the condition in the laboratory by putting cadmium plated articles in contact with copper naphthenate, but they had done no storage tests which proved that no other solutions were possible. It seemed good policy to avoid copper naphthenate when packing cadmium plated articles.

Mr. James said he had been surprised to observe, in the drop tests shown, that no use had been made of tensioned steel strapping and strengthening. Why was this?

Mr. Bulmer replied that they were in trouble with the manufacturers if they used tensioned steel wire in connection with fibreboard cases. Flat steel strapping might be all right, but wire was bad.

There was good reason for using strapping with wooden cases, but in the illustrations the cases were being used only for home trade or export to the Continent, and the strapping had not been used. He agreed that it should have been used. He was wholly in favour of such strapping for wooden cases but less in favour of its use with fibreboard cases, where it would cut in and would facilitate picking up the case by the strapping, thereby damaging the board.

Mr. John Ryan (*Vice-Chairman, The Metal Box Company*) said he was delighted that the subject of packaging products had been chosen for the Lecture because it was a vital subject in the whole range of their industry. In his experience, too little realisation of its importance had emerged. He had been interested in the subject for many years, and Mr. Bulmer's reference to war-time conditions had taken his mind back to a problem which had perhaps been given even more importance then than it was given now. In those days it was a question of life or death.

He had had the privilege of being Chairman of the Packaging Committee of the B.S.I., the first ever set up in this country. At one stage there had been 240 sub-committees dealing with different subjects, and out of that had evolved the Packaging Code, mentioned in the Paper.

We had been much indebted to the Americans for this progress. When they entered the War it was clear that in their Services they had paid particular attention to packaging and had gone much further than we had in producing standards. In the end, there was set up in this country the Anglo-American Technical Committee on Packaging, which viewed the subject with such importance that inspectors were appointed at every major port in the country — men who were skilled and knowledgeable about packaging and who made reports on the condition in which goods entered England. The extent of the damage being caused at that time by unsuitable packaging was amazing. It had also been amazing to see the way in which this had been put right when an appreciation of the problem was made. It was a problem not merely of the right package but also of the conditions in which the package had to be handled.

For instance, the Americans sent engineering goods to this country on pallets. This was an ideal method of packaging, but British ports had no means of handling goods in this way. This was an illustration of a case where the packaging was ideal but could not be used and where another package must be used to suit the handling conditions at the receiving end.

The extent of the damage at that time had been fantastic. He recalled being asked to examine the damage to radio valves. It had been found that 90% of the radio valves sent to the Services in the Far East were damaged. This had been discovered only by accident, arising from curiosity about the enormous numbers required. The Services had been quite happy about the situation, because they simply ordered 10 times as many as they required!

He recalled discussing the same point in Australia three years ago with a member of an important British firm which was beginning to manufacture in that country, but which put out many British goods in order to start the market. He had said that 90% of those articles arrived in Australia in too damaged a condition to sell.

It was a great pity that the approach to export packaging which he had described had been lost at the end of the War. Some people had had a very disappointing time in trying to alert industry to the importance of the problem. They had not been wholly unsuccessful, however, because one achievement had been the emergence of the packaging side of P.A.T.R.A. He was happy to feel that this had gone from strength to strength.

But packaging was very much more important than the question of the package itself. Mr. Ryan's Company perhaps made more packages than anyone else in the country, and this brought others aspects to their attention. For instance, it was now very clear that in many industries the cheap package which called for excessive packaging costs was a more expensive article than a package designed to produce the least cost in packaging. The Americans had done much work on this point. Investigations showed that the labour cost of putting goods into a package was often very much greater when putting them into a poor package than when putting them into a package designed to fit in with the production flow, so making the cost of packaging in a cheap container dearer than using a more expensive one.

Not only was packaging important from that angle but it could often be the means of winning or losing a market. He remembered one of the Company's products which, some years ago, had not been selling well in New York. The article was good and the price seemed right, but it did not break into the market. An investigation was carried out, and it was found that the reason it was not selling well lay in its packaging. The warehousemen in America, accustomed to another type of package, did not like handling this package and were persuading people that the article was no good!

He felt that many people did not realise the bad effects which unsatisfactory packaging had on their business, especially overseas. He recommended people to go abroad and see for themselves the results of good packaging. If they did, they would realise that they could not give too much attention to the problem.

Mr. A. R. Harding said he had been interested in the drop tests shown in the film. Had the Author any experience with the open type of package ?

Recently he had seen some electric motors which had been delivered quite safely to the customer in a very cheap crate which was left in such a manner that anyone could see what was inside. They had arrived quite safely simply because those who were handling the crates could see what was inside them. Yet this type of pack would obviously have not withstood the drop tests illustrated. Had the Author any experience of articles being left exposed and with only slight protection ?

Mr. Bulmer commented that for obvious reasons P.A.T.R.A. did not receive many examples of that type of pack in the laboratory.

There were two theories about packaging fragile articles. One was that there must be an elaborate pack to protect the article, which could be done by spending money. The second was that if the person handling the crate was allowed to see what was inside, he would handle it carefully. The carboy manufacturers made use of the latter theory. Glass was universally recognised as fragile and it could travel unprotected. The airlines encouraged this approach; they liked the open type of package. But their handling was very good and the airports in this country were usually very well equipped. It was also important to them to keep down weight.

But the theory could not be applied to everything. There were many instances in which a package would be loaded into a ship's hold, and something must go at the bottom. If all used the open crate, the stevedores and the many friends that industry possessed in the shipping companies would soon complain, as would Mr. Stewart.

In the export markets, too, it was necessary to think of climatic protection. The materials used for water vapour barriers were usually fragile and must be protected, for they were useless if punctured. It was no use putting a desiccant in a crate. But within limits it was feasible in packaging to permit the handler to see the product. It had its advantages, although if everybody did it, there would be trouble.

Mr. G. Wittenberg (*Rhoden & Partners Ltd.*) said that the labour costs of inserting the goods into the package had been mentioned in the discussion. In the case of small engineering products, such as sparking plugs, did P.A.T.R.A. do any work on the design features of a package for use in packaging machinery? Mr. Bulmer had said that he had not tested machinery, but it had to be remembered when one designed a cardboard carton, that the number of flaps, and where the flaps were placed, for example, had an immediate bearing on how such a package could be manipulated and closed by machine. Did P.A.T.R.A. deal with this ?

Mr. Bulmer, in reply, said that P.A.T.R.A. had done a great deal of work on such problems as the cutting and creasing of cartons, the width and depth of creases, the effect of pre-folding on stiffness and so on. Their research reports to their members were in advance of anything which other people had done.

So far their activities had been restricted to cartons and they had not carried them into the factory on the scale they would like. They had not been able to do any work study or operational research on a packaging line. This was on the research programme and he hoped that it would be done. P.A.T.R.A. had done a lot of work on cartons and were conscious of the need to extend the effort to other types of container.

Mr. Fransham said he was concerned with the packaging of aero engines. From the point of view of his work, the considerations which were of importance were the drop testing and the shunt testing. He found that the present drop test in DEF-1234 was realistic; if they designed a package to withstand a 2 ft. end drop, that was good enough. Apparently the 2 ft. drop was very rare in practice.

But the shunt effect was very common in practical experience, and in his opinion the DEF-1234 specification should be amended in respect of the frequency and severity of the 6 m.p.h. shunt test.

Mr. Bulmer, in reply, said that they were on fairly firm ground in saying that the DEF-1234 specification should be amended.

In discussions with contractors he had reached the conclusion that the majority of people thought that the drop test was all right. The consensus of opinion was that the shunt test was too severe, but in his opinion it was not severe enough. He thought the figure should be from 10 m.p.h., which he knew to be in line with what happened in practice.

Mr. Fransham said that his Company had made some observations on railway shunting which showed that 10 m.p h. was commonplace. His worst experience was on the Continent and in America, to some extent. In France they were extremely bad.

Mr. Bulmer replied that even on British Railways shunting varied very much from yard to yard. The Railways themselves were very conscious of this and were conducting a large number of tests to find out where it was bad and why. But for propaganda purposes they stuck to the figure of 8 m.p.h. One must certainly cater for more than that. In export tests P.A.T.R.A. usually allowed for impact speeds of 10 m p.h., but for home trade they normally did not go above 8 m.p.h.

Mr. Judges said that apparently P.A.T.R.A. dealt mainly with the packing-for-transport problem. Had they any answer to the problems of the receiving end, where goods were often badly unpacked by inexperienced people ?

Mr. Bulmer, in reply, said that that was a matter for education rather than for P.A.T.R.A. There were many instances in which even printed instructions were disobeyed. In fact, he had heard more than one user say that it was pointless to put ripper tape on the package because nobody used it. This was a problem which would be solved only by education. There was nothing that research could do about it.

Mr. Cannon said that, as manufacturers of accountancy machines and electrical machines, his Company found Australia particularly bad in the damage caused on arrival. Yet, when the same goods were sent to West Africa, where the port conditions were far less modern than in Australia, there were very few of these bad reports. Was this due to bad handling in Australia ? These packages were very bulky and heavy, weighing up to 1½ tons, and they ought to command good handling. Moreover, in West African ports they had to use lighters when the ship could not go alongside.

Mr. Bulmer said that the ports of the world varied a great deal. He had always regarded Japan as about the worst country from this aspect, with South America next, followed fairly closely by Australia. Although the facilities of the African ports were not always very good, they were blessed with a superfluity of labour, which might well be a contributing factor.

Mr. Howe referred to a drop test from 4 ft. 6 in. and asked whether the Author would consider that the correct drop height for commercial equipment. To what G level did he think commercial equipment should be designed ? What proportion of the works costs of an item ought to be spent on packaging ?

Mr. Bulmer, in reply, said they did not use a drop height of 4 ft. 6 in. for industrial packages. Judged by the fact that they were more often accused of over-testing than under-testing, they were probably right.

In the laboratory they had a number of schedules, which they had built up from their knowledge, of the journey hazards which had accumulated from the research projects over the last five years. These were used to test packages for any form of distribution. There were, for example, schedules for export British Railways mixed goods, passenger trains, British Road Services and worst of all, the Post Office. There was some modification of the schedules for individual jobs; for example, packages always seemed to suffer the worst handling.

For export tests they included drops up to 3 ft. 6 in. but for home trade they rarely included drops of more than 30 in., if they were not interested in postal distribution. If they were interested in postal distribution, they included drops up to 42 in.

They did not rely on one drop but did a series of drops, including the base and base edges — edge drops were more common than face drops. There were not many drops in transit which were dead flat. P.A.T.R.A. tended to rely on the edge drop a great deal and used sequences of perhaps 10 to 12 drops, testing more than one package. They started by using the largest face and then turned the package over and used the top as the base, covering all positions scientifically.

He would not attempt to answer the question about the G factor which equipment should be able to withstand. The G factor was by no means the only determining factor. There had been instances of identical pieces of equipment being tested in the laboratory, one breaking at 40 G and another being satisfactory at 90 G. In a problem recently a product was said to be sensitive to 40 G. It had been dropped on to a 3 in. pad of polyurethane — the shock was calculated to be 44 G for 29 milliseconds — and the equipment had broken. It had been dropped on to a pad of three thicknesses of corrugated fibreboard, which had given 99 G for 9 milliseconds, and the equipment had been all right. That package was still being used without trouble. It was necessary also to take into account the pulse duration as well as its intensity.

The cost of packaging was very variable and he did not wish to quote a figure. In packaging an expensive piece of equipment, costing several thousands of pounds, the cost of packaging could easily be less than 1%, even in a good package. On the other hand, with a cheaper piece of equipment or cheaper spare parts, the packaging cost might be almost equal to the cost of the equipment.

Mr. Hughes drew attention to the fact that in DEF-1234 there was no warning of what might happen in the event of a super-saturated desiccant through a puncture of the barrier. For example, the specification did not mention what would happen in the event of such a breakage in the barrier in a case of machinery. This raised the question of a waterproof barrier either below or in the vicinity of the area contiguous to the machinery. Could this be put right, because much damage had been done in this way ?

Mr. H. F. Read (*Manager, Export Packing Division, L.E.P. Transport Ltd.*) differed from Mr. Hughes in the suggestion that there was no mention in the specification of the protection of items from the possible effect of desiccant. If he read the British Standard on The Use of Desiccants (B.S.1133, Section 19) he would find that the point was specifically mentioned that there was a possibility of the desiccant media sifting out of the bag. This point had been raised very strongly in Committee. It was strongly recommended that goods should be covered with protective waxed paper prior to the sealing of the barrier. If this were done, any leakage through sifting, or a puncture of the M.V.P. Barrier, leading to the desiccant becoming saturated, would still leave partial protection.

Mr. A. J. Wills asked whether the Author had any information about such protective material as straw and cellulose films. Could he comment on the

protection used, for instance, cocooning, for high voltage electrical installations ?

Mr. Bulmer replied that he had a certain amount of information on cushioning material, particularly wood wool and paper wrappings and shavings. He had not used the cellulose film protection. He was not sure what information was sought; it was impossible to lay down general thicknesses or densities.

In answer to a further comment from Mr. Wills, that he was mainly interested in protection against corrosion through association with the media, Mr. Bulmer said it must be recognised that with all these things there was considerable danger of corrosion. Some cushioning materials were sprayed with formaldehyde, which could be oxidised to formic acid, and there had been numerous instances in which corrosion had been attributed to wood wool or paper shavings. In using paper, certain properties must be controlled closely, otherwise there was danger of corrosion. These properties were the chloride content, the sulphate content and the pH. The necessity for control was as important when it was being used as a cushioning material as when it was being used as a direct wrapping if it came into contact with metallic parts. It was necessary to ensure that any acid vapours from wood wool would not come into contact with metal.

Mr. Sivier (*Ministry of Aviation*) asked whether the packaging advisory service which P.A.T.R.A. offered to members was based purely on a " go or no-go " basis or whether, in addition to such tests, P.A.T.R.A. suggested modifications to the design of a pack, if necessary, or to the design and construction of the store.

Mr. Bulmer replied that they certainly did not consider it satisfactory merely to say: " We have tested your package and we find it unsatisfactory ". They liked to add a rider suggesting that modifications should be tried. In the design of the equipment, where prototypes were being tested, they stated that these could be improved, where this was the case, in no uncertain terms.

He emphasised Mr. Stewart's comment that packaging was a co-operative function which must start from the drawing board. P.A.T.R.A. always told members and others who sought advice that in the case of a new product, they liked to see the blueprints. There had been instances in which they had been able to save members considerable sums of money through slight modifications to their products.

In one instance of a well-known domestic refrigerator, it had been suggested that the heavy condenser unit should be mounted by two fragile struts, which would have been quite all right during the working life of the refrigerator, when it was moved perhaps only once or twice, but which were quite inadequate to withstand dynamic shocks during transit. P.A.T.R.A. had managed to persuade the design department of the firm concerned that by spending another shilling or two on better struts, they could save at least six shillings on packaging costs; they had so improved the design that the refrigerators could be despatched under little more than a dust cover!

Mr. Cannon suggested that it was " pie in the sky " to talk about the production people getting together with the packaging people during the design stage. In many companies the packaging man was out at the back. The equipment was designed and the instruction then given: " Pack it ".

Mr. Bulmer said that this was a point which he had tried to bring home in the Paper — that packaging must be a co-operative function and that it was possible to save money by bringing the packaging man into consultation at an early stage. He could not be the sole arbiter; the sales manager and the production departments must have their say. There were tooling costs to be considered, advertisement and the display value of packages, but the packaging man had a part to play. After all, a new product was not manufactured until it was believed that there was a market for it. It was therefore advisable at this stage to consult the packaging man, who could explain what the hazards were likely to be in that market and how to overcome them.

Mr. A. L. Stuchbery (*Chief Technical Engineer, The Metal Box Co. Ltd.*) proposing a vote of thanks to the Author, said it was a matter of great satisfaction to him to listen to a Paper which was not on a narrowly engineering subject, but which nevertheless was of vital interest to engineering.

The width of the Paper could be judged from the fact that it dealt with the packaging of engineering products and was thus as wide as the engineering products, multiplied many times by the conditions in which those products had to be handled and transported.

He thought that his task in expressing thanks to the Author was fairly easy, because those thanks had already been expressed by the extremely interesting and wide-ranging discussion. His task was, therefore, a formality of underlining and emphasising the thanks which the meeting had already accorded Mr. Bulmer. He asked the meeting to show by acclamation that the interest they had displayed by the discussion was a sincere indication of their appreciation.

The vote of thanks was carried with acclamation.

Mr. Bulmer expressed his thanks for the interest which had been shown in the Paper, for the problems which had been raised in the discussion and for the memento, which he would always cherish. If, on reading the Paper, members came across any problems on which they wanted further information, they had only to get in touch with him at P.A.T.R.A. House.

RECENT DEVELOPMENTS IN MACHINE TOOL COOLANTS

by V. J. HADEN, A.M.I.Prod.E.

Mr. Haden is employed by Shell-Mex & B.P. Ltd. as an engineer with special responsibility for metal working lubricants and coolants.

He was educated at King Edward VI Grammar School, Birmingham, and later studied at the Central College of Technology, Birmingham, for the degree in Metallurgy of London University. Prior to his present appointment he was assistant to the Chief Metallurgist and Machinability Research Manager of the B.S.A. Tools Group.

Mr. Haden gave this Paper to the Birmingham Section of The Institution of Production Engineers on 20th January, 1960.

THE use of coolants flooded on to the work in a machine tool in the way we know it today is a relatively new practice, and engineers will remember the time when it was customary to brush on a little oil or suds from a can, or to accept a dribble by gravity from a container of about one gallon capacity. They may also remember grindstones which dipped into a sump filled with water, where the only circulation was that provided by the wheel itself.

Water was, in fact, almost certainly the first coolant used in metal working. The alternative fluids most readily available to the early machinists would be oils derived from animal or vegetable sources. These, typified by lard oil and rape seed oil, are today called fatty oils to distinguish them from petroleum oils derived from mineral sources. The use of fatty oils persisted in some cases up to the outbreak of the Second World War, although already blends of mineral oils with suitable additives had been developed and the superiority of these was recognised in many machine shops.

Side by side with the use of neat oil, various substances had been tried in combination with water in attempts to avoid its tendency to rust, and to increase its lubricating power whilst still making use of its excellent cooling properties. Soap solutions were most satisfactory and their use was common up to the mid-twenties, although again practical soluble oils were commercially available towards the end of the First World War.

The steady development between the Wars was naturally accelerated by the great expansion in

Fig. 1.

machining which began in the late 'thirties. Both during the Second World War and since there have been substantial advances, and to appreciate these it is necessary to review briefly the principles of formulation of cutting oils. It is most convenient to consider neat oils before turning to solubles.

Mineral lubricating oils are obtained by fractional distillation of crude petroleum and thus are available in a wide range of viscosity. They can be further refined to give very stable fluids virtually inert to metals and alloys. They provide good fluid lubrication but used alone they cannot support the very heavy loads at the tool edge. Fatty oils are less stable; they attack some metals and become rancid in use but they provide better lubrication in the conditions under review. These excellent boundary lubrication properties persist when the fatty oils are blended in relatively small percentages with mineral oils, and by suitable selection blends are produced which have good stability combined with excellent cutting properties.

With demands for higher rates of metal removal and for the ready machining of tougher alloys, such blends soon reached their limits of usefulness. It is worthwhile recalling that in the 'thirties many machine shops considered steels of 65 - 70 tons tensile to be very difficult to machine. Today such steels are regularly machined without difficulty, even on automatics, and developments in machining stainless and heat-resisting alloys have been even more striking.

The use of "extreme pressure" additives probably originated in the advantage, discovered by chance, of the addition of a little "flowers of sulphur" (a form of sulphur obtained by slow distillation of other forms) to the cutting oil. When the mechanics of this were examined, it was suggested that at the high temperature of cutting some of this sulphur reacted with the metal surface. Since iron sulphide has a lower melting point than steel it is conceivable that, when normal lubrication fails, the minute film of sulphide fuses and provides momentary lubrication. Similar phenomena occur when chlorine or phosphorus are added in suitable forms.

Hence a range of cutting oils is available as follows:

1. Straight mineral oils — suitable only for light duty high speed work.
2. Blends of mineral oils and fatty oils — suitable for light and medium duty.
3. Mineral oils plus E.P. additives — suitable for the heaviest duty.
4. Blends of mineral oils with fatty oils and E.P. additives — suitable for the heaviest duty.

In practice the first and third classes have limited usefulness, for reasons which can be seen in Fig. 1.

Under increasing stress, due to pressure from the tool, metal in front of the tool tip distorts and eventually shears. The load on the tool is highest at the extreme tip and, with tough materials, cannot be supported by oil alone. Therefore, chips tend to weld to the tool and this is controlled by the use of extreme pressure additives. These, however, are only effective at high temperatures and under extreme pressures. Both temperature and pressure diminish away from the tool tip and just before the chip curls away, the load can be sustained by the mineral oil. In the zone between, oiliness is vital and it is here that fatty oils play their part.

One method of assessing load carrying capacity of lubricants is by the use of the Shell Four Ball Machine. Three ball bearings are clamped in a fixture and a fourth, held in a chuck, is rotated under load in the recess thus formed (Fig. 2). The load is increased until welding is incipient and the deflection plotted. By measuring the wear scar, the unit loading which the oil will carry can be assessed. Fig. 3 shows a series of load-wear diagrams thus obtained. All the oils, except Shell Garia Oil A, were of the same viscosity and the curves show how the load carrying capacity increases when fatty oils and extreme pressure additives are incorporated.

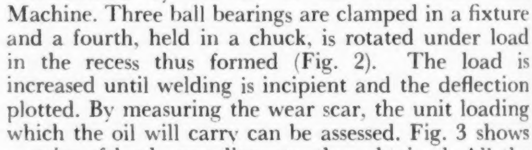


Fig. 2.

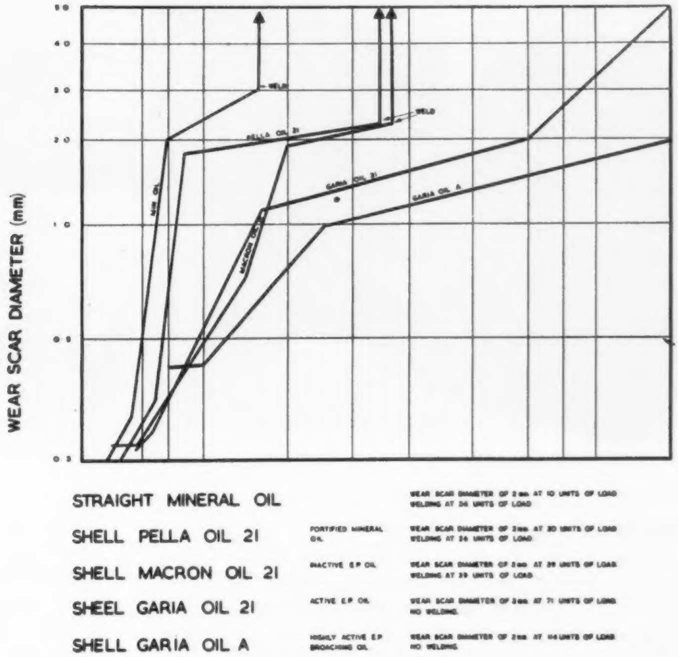


Fig. 3.

sulphurised cutting oils

Of the extreme pressure agents available sulphur is the most generally useful, and it has an especial advantage in that it is free from objectional physiological effects. Some of the early sulphurised fats were very strong smelling, but careful attention is given to this nowadays and good quality additives substantially free from odour are available.

Again, at one time a prominent disadvantage was the risk of attack on yellow metals. Elemental sulphur will disolve in mineral oil to the extent of about 0.5% but in such a form it attacks copper, brass and some bronzes quite severely even at room temperature. If, however, the sulphur is heated with a suitable fatty oil in the presence of a catalyst it forms a loose chemical combination which reduces the activity of the sulphur and inhibits such attack. Nevertheless, under the conditions of high temperature and pressure in the cutting zone the combination breaks down and the sulphur again becomes available as an extreme pressure agent. Early blending techniques gave only limited control and it was usual to distinguish between "active" and "inactive" cutting oils according to whether or not they attacked yellow metals at room temperature.

The "active" oils were accepted as necessary in machining tough steels, but could not be used on brass or bronze. Moreover, they caused difficulty on machine tools which had yellow metal components in the cutting zone. An extreme case was the bronze bearing in the slide block on multi-spindle automatics; with an oil which was too active a sulphide film would build up and cause the slide to seize (Fig. 4). Hence at one time makers of such machines advised users to avoid sulphurised oils. Recent improvements in blending techniques have given very precise control over the activity of sulphur in cutting oils. By the use of these methods and by careful selection of sulphurised fats, it is now possible to blend sulphurised cutting oils which are adequate for the severest duty and yet may be used with confidence in all types of machine tools.

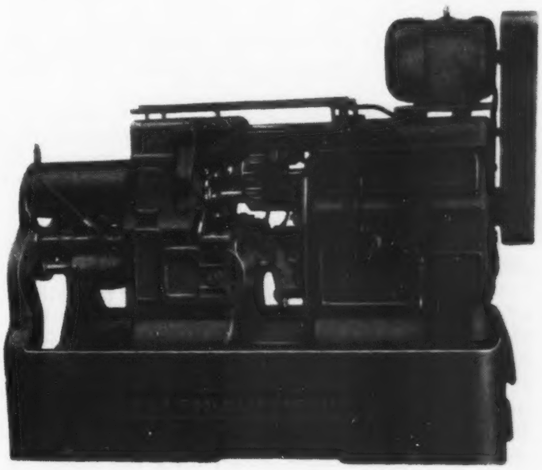


Fig. 4.

Fig. 5.

chlorinated cutting oils

Chlorine has been less widely used than sulphur as an extreme pressure agent in cutting oils. Frequently it is used in the form of a chlorinated hydrocarbon, that is, a part of the hydrogen in the hydrocarbon molecule is replaced by chlorine. Oils containing such additives alone may be compared with blends of mineral oils and mineral sulphur alone in that they lack the valuable intermediate boundary lubrication property of the sulphurised fatty oil/mineral oil blends. On the other hand, chlorinated additives may be highly active towards steel and yet not stain yellow metals. This is a less prominent advantage now that such precise control is available over the activity of sulphur.

It has been claimed that combinations of sulphur and chlorine are especially valuable in that the two elements are active at different temperatures and, therefore, that sulpho-chlorinated oils are useful over a wider range of cutting conditions. In practice it has proved difficult to take advantage of this, but it is claimed again that certain additives containing sulphur and chlorine in the same molecule overcome this difficulty.

Some operators have proved sensitive to certain chlorinated blends which has limited their usefulness but, as will be shown later, chlorine is essential in certain machining operations and future development may widen its useful field of application.

development of low viscosity heavy duty cutting oils

In machining the general rule is that as the severity of the operation increases, the speed of cutting falls. Heavy roughing cuts are taken at low speeds and for light finishing cuts the speed is increased. Tough steels are cut at much lower speeds than free machining brass. For this reason, and also because many of the early additives used were themselves viscous, it was accepted that heavy duty cutting oils should be thicker, more viscous, than those used on high speed lighter work.

More recent developments in machining techniques have shown that very high speeds can be attained with satisfactory tool life and finish on operations which were traditionally performed at low speeds. Typical examples are high speed hobbing of gears, boring and trepanning and, more recently, broaching. For gear hobbing as long as cutting speeds were restricted to, say, 85 - 90 s.f.m., it was customary to use heavy, viscous, oils. When these speeds were increased to the 200 - 250 s.f.m. range it was found that much lighter, lower viscosity, oils gave better tool life and finish although such grades, as then available, were of lower additive content than the grades customarily used.

About the same time a demand arose for special coolants suitable for high speed deep hole boring. Machines were being developed, notably by R. L. Carlstedt of Sweden, now Asplundverken A.B. of Stockholm (Wickman Ltd., Coventry) simultaneously with special boring tools by Gebrueder-Heller of Bremen, for producing accurate straight bores with very high surface finish at rates of penetration of 6 in. per minute or more depending on the type of components to be bored (Fig. 5). These machines also demanded a low viscosity coolant capable of working under severe conditions. The need was finally met with blends of low viscosity mineral oils with specially selected sulphurised fats. Mineral oils were chosen which had exceptionally good temperature/viscosity characteristics so that the finished blend would not thin out as the oil warmed up. The viscosity is of the order of 95 seconds Redwood 1 at 70°F, whereas a conventional oil for similar duty would be about 650 seconds at the same temperature. Whilst originally developed for deep hole boring, the oil has proved highly suitable for high speed gear hobbing and for a wide variety of high speed high precision work.

The development of heavy duty broaching coolants for heat resisting and stainless materials followed a different pattern. The production of " fir tree " roots for blades and discs was a serious bottleneck in the manufacture of gas turbines, and the demand for

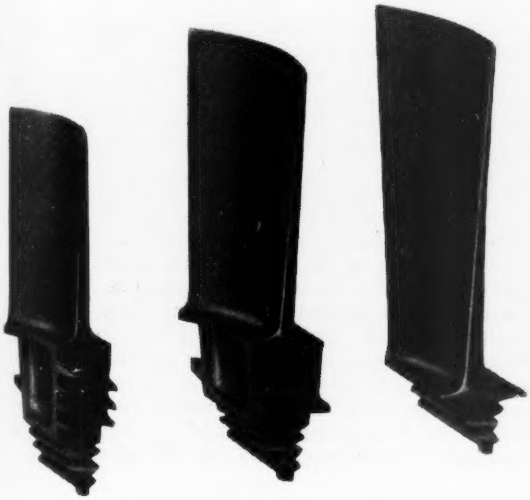


Fig. 6.

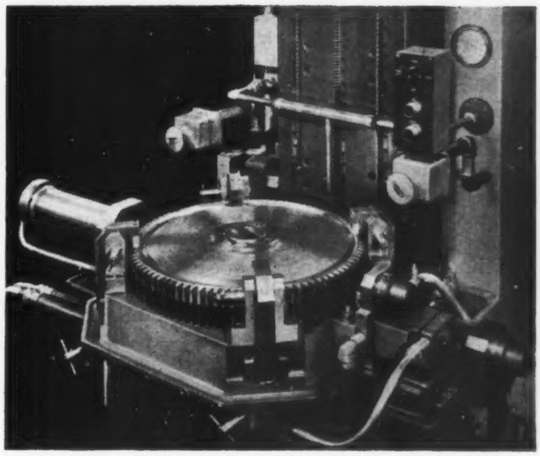


Fig. 7.

these engines led to highly developed techniques in broaching both the male root of the blade and the mating slot in the disc (Figs. 6 and 7). Conventional cutting oils with even the highest additive content gave poor finish and short tool life and for several years blends of highly chlorinated solvents, such as carbon tetrachloride, and fatty oils were used. The solvents were expensive, volatile, and more serious still, gave off toxic fumes. The need for highly efficient fume extractors on the machines meant increased capital costs and also increased the loss of solvent. In spite of their disadvantages, the machining problem was so serious that these blends had to be used.

The health aspect especially pointed to the need for alternatives and intensive research was put in hand in the laboratories both of the oil companies and chemical manufacturers. The first essential was a source of freely available chlorine in a less obnoxious form. Viscous oils, accepted in conventional broaching, had been shown to be unsatisfactory, so the final blend must be fluid. Oiliness and activity needed to be balanced for it was shown that too high oiliness gave poor finish, too high activity led to excessive broach wear. Slowly a series of broaching fluids emerged based mainly on new chlorinated hydrocarbons, containing very high percentages of chlorine but differing from their forerunners in that they were liquids instead of solids. Blended with low viscosity mineral oils and suitable fats, the most recent coolants of this type give tool life and surface finish equal to the less attractive volatile media. They are free from unpleasant odour and toxic fumes and are far more economical in use. Whilst developed primarily for the broaching of stainless and heat-resisting alloys, their efficiency is so high that they are now widely used on more conventional materials such as medium tensile steels and even malleable and cast iron.

the impact of cutting oil reclamation

In all machining operations a certain amount of the cutting oil is carried away with the swarf. In a general machine shop recovery of this may not be worthwhile, but even a small battery of automatic lathes will warrant the installation of suitable plant. The swarf is "spin-dried" and the oil collected (Fig. 8). It should then be heated to 140° - 160°F and filtered or centrifuged before re-use. This heating not only sterilises the oil but also thins it out and thus assists filtration or centrifuging.

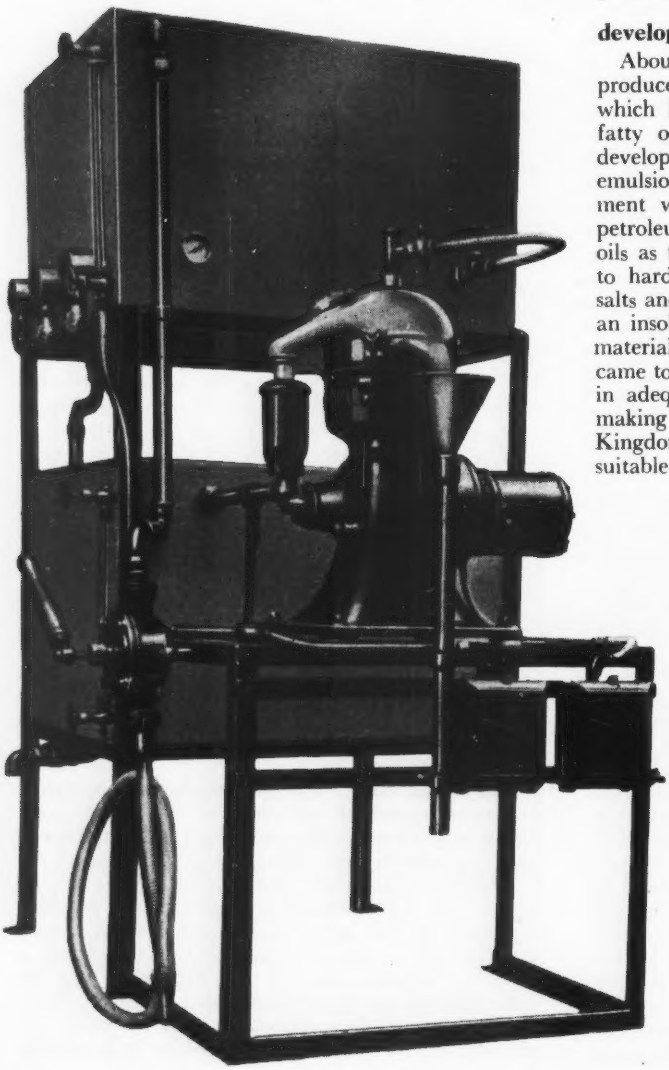
Most operators of such systems realise that the recovered oil is less efficient than new, but the reason for this is not always clearly understood. Cutting oils are seldom adversely affected either by use or recovery; the problem is rather one of adulteration by machine oil. The types of machines, principally bar automatics, with which recovery is important often have a high proportion of "total loss" lubrication — the lubricating oil passes through the bearings once and then runs into the machine sump. In one cycle the dilution of the cutting oil is negligible, but with efficient recovery the oil is used many times and examination of samples has shown that a ratio of one-third lubricating oil to two-thirds cutting oil is not uncommon.

This can be made good by addition of a concentrate or the recovered oil can be used on lighter duty. Either course complicates procedure and the first can lead to excessive costs unless carefully controlled. An alternative which is growing in favour is to use the same oil for lubricant as for coolant. Many machine tool builders will agree to this provided that only inactive cutting oils are used, that only new oil is used as lubricant and that the cutting oil has the same viscosity as the recommended lubricant. Even if all these provisos cannot be met by using the identical oil for lubricant and coolant, it is possible

to select a suitable cutting grade for lubricant which will reduce substantially the effects of adulteration. In this way, the operator is assured of consistent quality of his coolant and is not faced either with having to vary conditions of working or to have to make additions of concentrate to the machine.

soluble oils

Another field of development in coolants is the addition of various substances to water to improve its lubricating power and to reduce its tendency to rust. For cutting operations as distinct from grinding, soap solutions came into common use and were used up to the mid-twenties, although by that time practical soluble oils were commercially available. The principle of using these soluble, or more properly emulsifiable, oils seems to have been conceived about 1917, when a period of unprecedented expansion in machining coincided with a serious shortage of soap.



In the simplest terms soluble oils are blends of light mineral lubricating oils and emulsifiers. If oily hands are rubbed with soap a crude soluble oil is formed, and when the hands are rinsed the oil is emulsified more or less successfully, depending on how much soap is used and how thoroughly it has been rubbed in.

The early soluble oils contained emulsifiers based mainly on sulphonated fatty oils and resin soaps, and were fairly satisfactory except that they were sensitive to the hardness of the water. Hard water contains soluble salts of calcium and magnesium and the calcium salts in particular react with these types of emulsifier to form insoluble soaps. Hence the soluble oil is robbed of part of its emulsifier and the emulsion or slurry is less stable. This could be overcome to some degree by softening the water with washing soda or by using a stronger emulsion, but the first procedure is complicated and the second expensive.

development of petroleum sulphonates

About 1929 new methods of refining mineral oil produced as a by-product petroleum sulphonates, which have some of the properties of sulphonated fatty oils. Emulsifiable oils based on these were developed in Germany to produce anti-corrosion emulsions for marine ballast, and further development work in Britain produced soluble oils using petroleum sulphonates in place of sulphonated fatty oils as the main emulsifier. These were less sensitive to hard water, since the reaction between calcium salts and the petroleum sulphonates does not produce an insoluble soap. However, in 1939 imports of this material from Germany, the principal source, naturally came to an end, all emulsifiers were difficult to obtain in adequate quantity and great difficulties arose in making soluble oils. Oil refining in the United Kingdom expanded rapidly after the War and as suitable materials became more freely available, substantial improvements were made.

An important milestone was the publication by the Production Engineering Research Association between 1949 and 1951 of a very full series of reports on the subject. These showed that whilst the effect on tool life of a wide range of soluble oils was not substantially different, there were important variations between them in emulsion stability and the protection given against corrosion. Attention became concentrated on these aspects, especially the latter, and it is here that great improvements have been made.

Fig. 8.

The test originated by Lloyd and Beeney, elaborated and accepted provisionally by the Institute of Petroleum, is designed to simulate the effects of steel chips wetted with soluble oil lying on a machined cast iron surface. The mechanics of corrosion under these circumstances are not completely understood and the approach to a solution of the problem is mainly empirical. It is known that certain combinations of emulsifiers give satisfactory results and also that an increase in alkalinity improves the degree of protection. There are limits to the degree of alkalinity which is acceptable, since it is found that emulsions which are too alkaline lead to soreness and chapping of the operators' hands and arms. Satisfactory compromises are found around pH 9.0 to 9.5 and if these figures are exceeded, care is necessary.

importance of emulsion stability

Obviously emulsion stability is of the highest importance, since however good the new emulsion may be it will deteriorate seriously if it separates. Here very great improvements have been made. At one time it was usual for a freshly mixed emulsion to separate over a relatively short period, so that oil was abstracted by the swarf and regular additions were necessary to maintain the strength and prevent rusting. The problem today is reversed and evaporation of water in the cutting zone leads to excessive concentration. Regular checking of soluble oil emulsions is frequently necessary to avoid this excessive concentration, which again may cause sore hands.

Increasing rates of metal removal on machines which traditionally use neat cutting oils have in some cases led to complaints of excessive fuming and smoking, and in particular this has been associated with chucking automatics when carbide tooling has been used to allow increased production. Provided the whole of the tooling can be done with cemented carbides and if adequate protection is given to machine parts, conventional soluble oils can often be used, but if carbide and high speed steel tools are mixed the results with soluble oil emulsions may be disappointing. To meet this difficulty special soluble oils have been developed, containing the same types of extreme pressure additives which have been useful in neat oils. Fig. 9 shows a comparison of laboratory drilling tests using one such oil with those using a conventional grade. This particular extreme pressure soluble oil contains a very high percentage of sulphurised fat and even when mixed with water at 10 : 1 the emulsion contains about the same amount of such fat as would be found in a typical neat auto oil. This, together with the cooling power of water, provides a combination extremely useful in difficult cutting conditions. On operations such as drilling and milling where neat oil is not acceptable to the operator, and yet where the work is so heavy that a conventional soluble oil gives poor tool life, very substantial savings in regrinding and tool settings are possible.

Drill No	Conventional soluble oil Concentration 10%	Typical neat auto oil	Shell Oil S 3459 Concentration 10%
1	87	524	1,005
2	139	722	1,540
3	35	241	672
4	80	185	900
5	307	612	1,520
6	214	542	1,143
Average	144	471	1,130

Comparative Test Data:
Drill: 0.3125 in. dia (HSS)
Speed: 1,200 rpm.
Feed: 0.010 in/rev.
Depth: 0.750 in. (blind hole)
Materials: B.S.328 tyre steel
Holes drilled at random. All steel from same batch.

Fig. 9.

The manufacture of these grades is rather difficult, involving chemical reactions rather than simple blending and special equipment may be necessary. The Author's Company has decided recently to take soluble oil blending right out of the general lubricating oil plant and to establish specialised plants for their manufacture. Figs. 10 and 11 show important steps in the making of soluble oil. Here we see the first step where constituents which are solid at room temperature are heated in the barrels and dropped into floor tanks. The fatty oils are added with a part of the mineral oil and further heating and stirring

Fig. 10. Preliminary heating of solid and semi-solid constituents. (Note barrel heater on left-hand tank.)

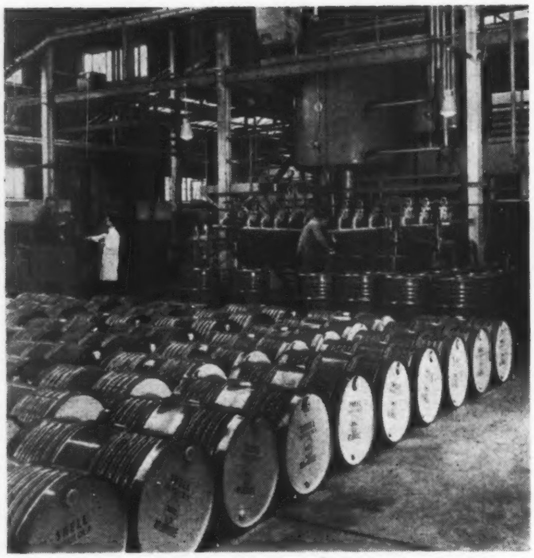


Fig. 11.

gives a fluid blend. This is partially neutralised to form the soaps and it is pumped to overhead storage tanks. When a blend is to be made, sufficient of this soap or concentrate is run into the final blending kettle where it is heated by steam coils and the remainder of the mineral oil added. The acidity is adjusted to very close limits and final additions made.

During this stage (Fig. 12) the kettle is sealed and mechanically stirred, thus avoiding loss of any constituents which may be volatile at the blending temperature. Certain substances — notably phenolic compounds — which have been accepted as essential in soluble oils have recently become suspect as possible skin irritants. The most satisfactory alternatives are

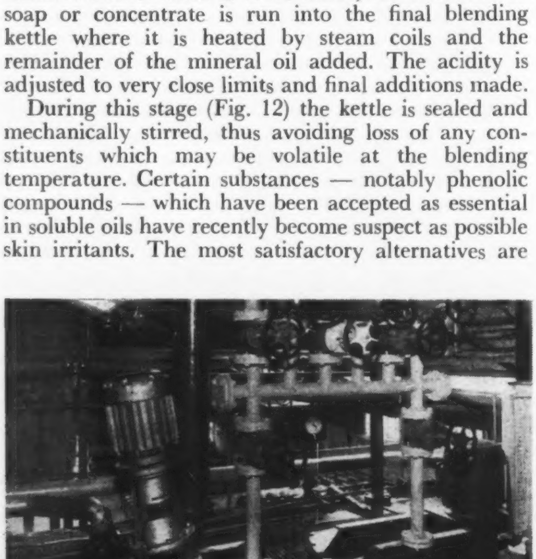


Fig. 12. Soluble oil, final blending stage, showing top of sealed blending tank with mechanical stirrer and reflux condenser behind flame-proof electric motor.

the higher fatty alcohols and one of the objects in designing this plant was to allow the use of these alternatives and so produce soluble oils which are more acceptable to machine operators.

grinding fluids

In precision grinding the very oiliness of soluble oil emulsions is often undesirable. For many years solutions of sodium carbonate (washing soda) were used but recently more refined alternatives have been developed. Mainly these are solutions of sodium nitrite and triethanolamine which inhibit rusting. Their use demands a certain amount of care since, unlike soluble oils, they are electrolytes. Hence when unlike metals are in contact, corrosion can be accelerated rather than inhibited.

Grinding machines are generally simpler in construction than cutting machines, with well protected slides, and if the machines are cleaned down regularly, if maintenance is good and if electric motors are protected, little trouble arises. More attention to lubrication is desirable and preferably surfaces clamped in contact should be previously oiled. If, however, these fluids are applied to cutting machines severe corrosion may occur and whilst in certain operations very great advantages have been claimed, the associated difficulties have prevented their regular use.

Another difficulty has been that the solutions in certain cases concentrate quite rapidly. When too strong they stain and coarsen the skin and sores may develop. With certain formulations a simple test based on specific gravity will determine the concentration, with others laboratory work may be necessary. In either case regular checking and correction of strength is essential.

facilities for research and development

The machine tool is the very basis of industrial development and a rising standard of living as far as material aspects are concerned depends on its efficient use. Producers both of oils and additives appreciate the importance of the market and devote to it much research. The problems are examined in chemical, physical and metallurgical laboratories and the results tested in engineering laboratories all of which are maintained on a large scale. Work to similar ends proceeds continuously in the laboratories of machine tool builders and users, whilst associations such as The Production Engineering Research Association play an important part in both independent and sponsored research. Many important investigations have to be made actually in machine shops because the conditions cannot be reproduced satisfactorily in the laboratory.

From the resultant very large volume of work — both published and unpublished—it has been possible in the scope of this Paper to discuss briefly only some of the developments brought to successful conclusions.

acknowledgments

The Author acknowledges his indebtedness to Shell-Mex & B.P. Ltd. for permission to publish the results quoted; and to Wickman Ltd., B.S.A. Tools Ltd., Alfa-Laval Ltd. and Weatherley Oilgear Co. Ltd. for permission to use certain photographs.

A VISIT TO POLAND

reported by F. W. COOPER, M.I.Mech.E., M.I.Prod.E.

Education Officer to the Institution

IT was with pleasure that I learned that Council had decided I should give a Paper, on behalf of the Institution, to the Polish Society of Mechanical Engineers and Technicians (SIMP), a body with whom we have had, for some time, close and pleasant relations. The subject was to be "The Education in Great Britain of the Young Production Engineer", to be given in Warsaw at a conference for Industrial Training Officers and others on the "Methods of Training Young Technologists in the Field of Production Engineering". Other Papers were to be given by Dr. Kaczmarek, Director of the Metal Cutting Research Establishment in Cracow and by Dr. St. Wojciechowski of SIMP both dealing with the same aspect, but from the Polish point of view.

I hoped that this visit would also give me the opportunity to see how Warsaw, 85% completely destroyed during World War II, had indeed risen from the ashes; to see a little of the culture of which the Poles are so rightly proud; to observe the industrial and educational progress made since the War and to get to know at least a few of the Polish people, for whom I had always held a sincere admiration. I shall always be grateful to the Institution, and in Poland, to SIMP, for providing the opportunities to do these very things.

impressive rebuilding programme

Warsaw indeed was a great surprise, for not only has the opportunity been taken to build some excellent main thoroughfares with many offices, shops and flats, but the old town buildings have been restored and even completely rebuilt in the traditional style. What a delightful picture is presented by the old Market Square! That many of the newer buildings seem a little drab is almost entirely due to the fact that they await stone facings — but it was obviously very sensible to build and occupy without delay, leaving the trimmings until time and money were available. The Grand Hotel in which I stayed as a guest of SIMP was excellent by any standard and the food, as indeed throughout Poland, was very varied and good. The Palace of Culture, of height over 700 ft., and built by the Russians, may not be in appearance to everyone's taste but inside the building it is quite a different matter and full use is made of the excellent cinemas, theatres, lecture halls, art galleries, etc.

Poznan was reached by rail through country very largely agricultural and, if possible, more flat than Holland. The city was overflowing with visitors to the International Fair and it appeared that all the major countries were represented. The British stands gave a fair coverage, but since it was my first visit to Poland I was naturally interested in their exhibits such as machine tools, ceramics, agricultural machinery and produce. Whilst in Poznan a visit was paid to the works of H. Gegielski, producing machine tools (largely automatic and turret lathes, radial drills and hydraulic-feed bar cutters), large diesel marine engines, up to 1,500 b.h.p. per cylinder at 119 r.p.m., and metal-bodied railway coaches. In particular, production of the latter seemed most efficient with some good fabricating and welding fixtures for the roof, sides and chassis.

The next journey by train sleeper took me to Cracow, a lovely old-walled town, mercifully spared during the last War and full of architectural gems. The Market Square is the focus of activity and the vista afforded by the Clothier's Hall and St. Mary's Church is delightful. Visits to Wawel Castle, the old University, a country area which reminded me of our Peak district, and to the "Wianki" firework festival on the Vistula will always be recalled with pleasure.

A visit was paid to the Academy of Mining with its many faculties including engineering, geology, surveying, metallurgy, electrical engineering and machine construction. The underground workings are most complete and many of the walls are lined with coal-cement blocks providing a cuttable coal face. Many types of cutters, loaders and conveyors, including some from Great Britain, are in regular use. An annual "output" of 250 students is in keeping with the importance of the coal industry in Poland. Having no expert knowledge in this field, I can only hope that in Britain we have but a fraction of what I saw in the Academy.

Also visited was the Metal Cutting Research Establishment (IOS) where under the guidance of Professor Kaczmarek some most interesting work was seen on surface grinding, "piecemeal" tools, ultrasonic and spark machining, metal cutting, fine measurement including surface finish standards, and the production of ceramic tips. The more I see of industry and research in emergent countries, or a

country like Poland which virtually made a fresh start in 1945, the more I hope that somewhere in Britain we have the vitality, the untrammelled outlook and indeed the right men and facilities to keep abreast, let alone in front, of such countries. From the educational point of view I become seriously alarmed when I think of Aachen, Moscow, Delft and now Poland. No time is wasted there in asking if production engineering is respectable or scientific or even accurately definable. National interests cut right across such time-consuming and futile exercises and some of the country's best brains are thereby encouraged, and do enter, this field. So much time here has already been lost — can we gamble on tomorrow always being there?

However, and more cheerfully, back to Cracow with Sunday in the beautiful Tatra mountains and then a return by train sleeper to Warsaw. Mr. Idzkiewicz, who had accompanied me from Poznan onwards, had translated my Paper and this had been excellently duplicated by SIMP and issued to all those attending the Conferences. Mr. Idzkiewicz was also my translator for a much shortened version given at the Conference itself. The SIMP Conference was very well attended by industrial training officers from all over Poland and in addition to the three Papers given on academic and industrial training, six of the training officers present gave detailed statements on their own particular problems, problems which indeed seemed little different from our own. On the academic side the training of technologists, technicians and craftsmen is on more clear-cut lines than our own, but many problems appear to rise concerning the absorption of technologists. Several of the speakers expressed interest in "sandwich" schemes as an efficient way of correlating academic and practical training. The Conference lasted about five hours and to me seemed to serve a very useful purpose, not in the least that of bringing training officers together.

warm hospitality

It was typical of the many kindnesses received from the officers and members of SIMP that the three to whom I owe the most for a very pleasurable and instructive visit, Mr. Jan Legat, Secretary General to SIMP, Mr. Latour and Mr. Idzkiewicz were awaiting me (all with many gifts) at the Air Terminal Building in Warsaw at the grisly hour of 6 a.m., later to see me safely on the plane for London. For my part I can but hope that I helped to cement even more firmly, the friendship that already exists between Stowarzyszenie Inzynierow I Technikow Mechanikow Polskich and the Institution of Production Engineers.

POLISH ENGINEERS IN BRITAIN

Right: **An interesting point is explained to the visitors at the works of J. Stone & Company (Deptford) Limited.**

Left: **The visitors at the works of G. A. Harvey & Co. (London) Ltd., where they were welcomed by the Joint Managing Director, Mr. D. K. Fraser** (centre of photograph).

POLISH ENGINEERS VISIT BRITAIN

sponsored by The Institution of Production Engineers

OVER the past few years, the Institution of Production Engineers has maintained a close liaison with the Polish Society of Mechanical Engineers and Technicians, and there have been several exchanges of visits between the two associations.

The first exchange of visits took place in the Spring of 1958 when a party of 15 - 20 members of this Institution visited Poland, and a similar number of Poles visited this country.

Under the auspices of the Polish Society, Mr. G. Ronald Pryor, President of the Institution, made a special visit to Poland in 1959, and more recently Mr. F. W. Cooper, the Institution's Education Officer, attended a conference in Warsaw, in June, 1960, when he delivered a Paper entitled "The Education in Great Britain of the Young Production Engineer".

The most recent visit of members of the Polish Society of Mechanical Engineers and Technicians, which was sponsored by the Institution, was in June of this year, when a party numbering 19 came to London. Their tour, which was arranged by the Institution, included visits to the Machine Tool Exhibition, Olympia; the National Physical Laboratory, Teddington, and the following Companies :-

1. Fuller Electric Ltd., Walthamstow.
2. G. A. Harvey & Co. (London) Ltd., London.
3. Hoover Ltd., Greenford.
4. Metal Box Co. Ltd., Rochester.
5. Power-Samas Accounting Machines Ltd., Croydon.
6. J. Stone & Co. (Deptford) Ltd., London.

Their itinerary also included sightseeing tours, and a visit to the cinema. The Institution would like to record its appreciation to the Organisations and Companies mentioned above for their generous hospitality, and the way they did all within their power to make these visitors welcome.

It became clear in discussions which were held with the engineers visiting the United Kingdom that they are aware of modern production techniques but lack the resources to utilise them. In addition the Polish Government is spending considerable sums of money on establishing research laboratories, and British industry would do well to be aware of the rapid advances being made in Poland today.

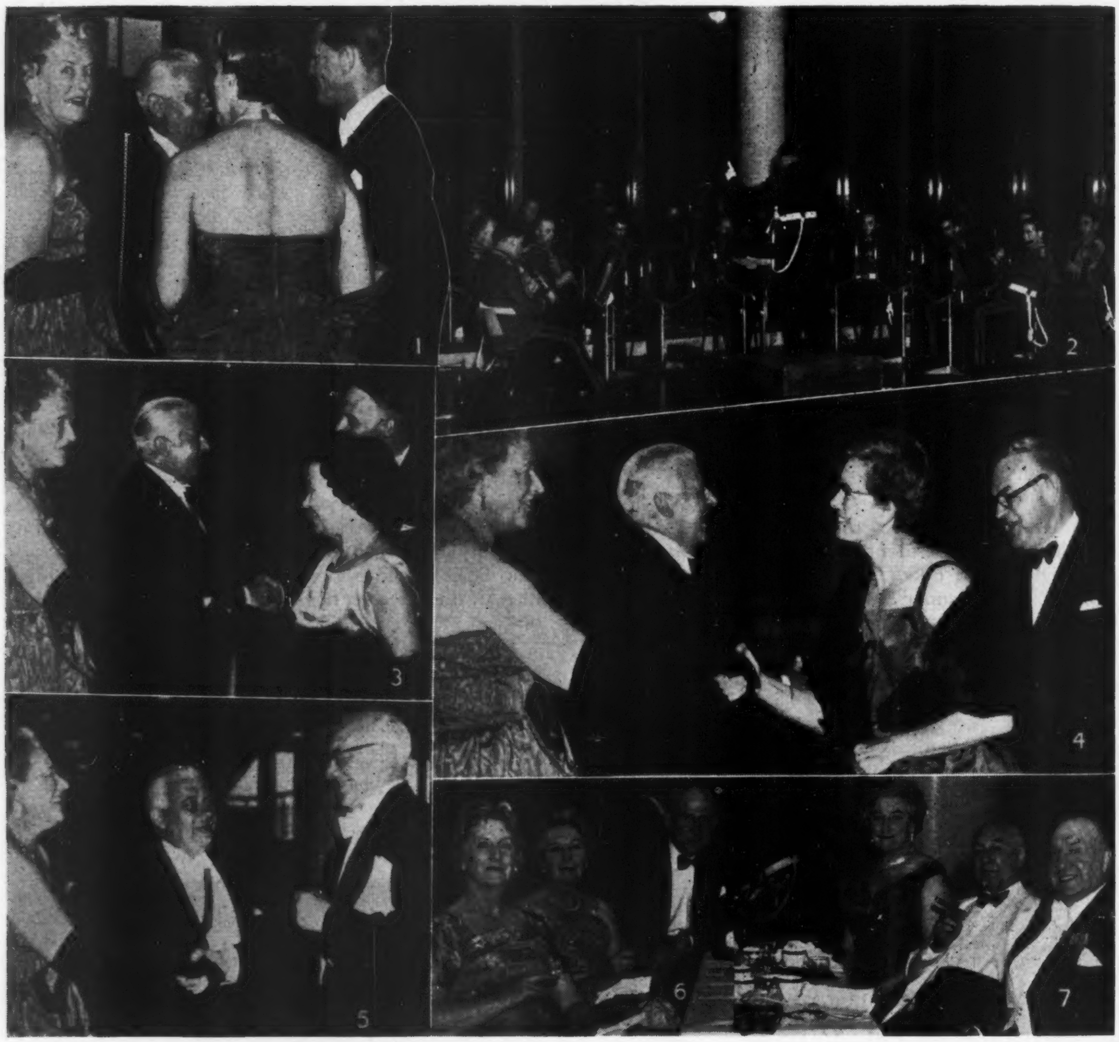
future exchange visits

Further exchange visits could be of mutual benefit to both countries and one suggestion that has been put forward by the Polish Engineers is the possibility of an exchange of engineers for working periods of about one month; comments from members of the Institution on this type of activity would be welcome. The Poles would also welcome lectures from leading men in the research field, particularly from Universities.

In addition to the obvious educational value of these exchange visits, they are also of immense benefit in promoting good relations between the two countries, and on an individual basis many lasting friendships have been created.

The party of Polish engineers photographed outside the works of Fuller Electric Ltd.

CONVERSAZIONE, ROYAL FESTIVAL HA

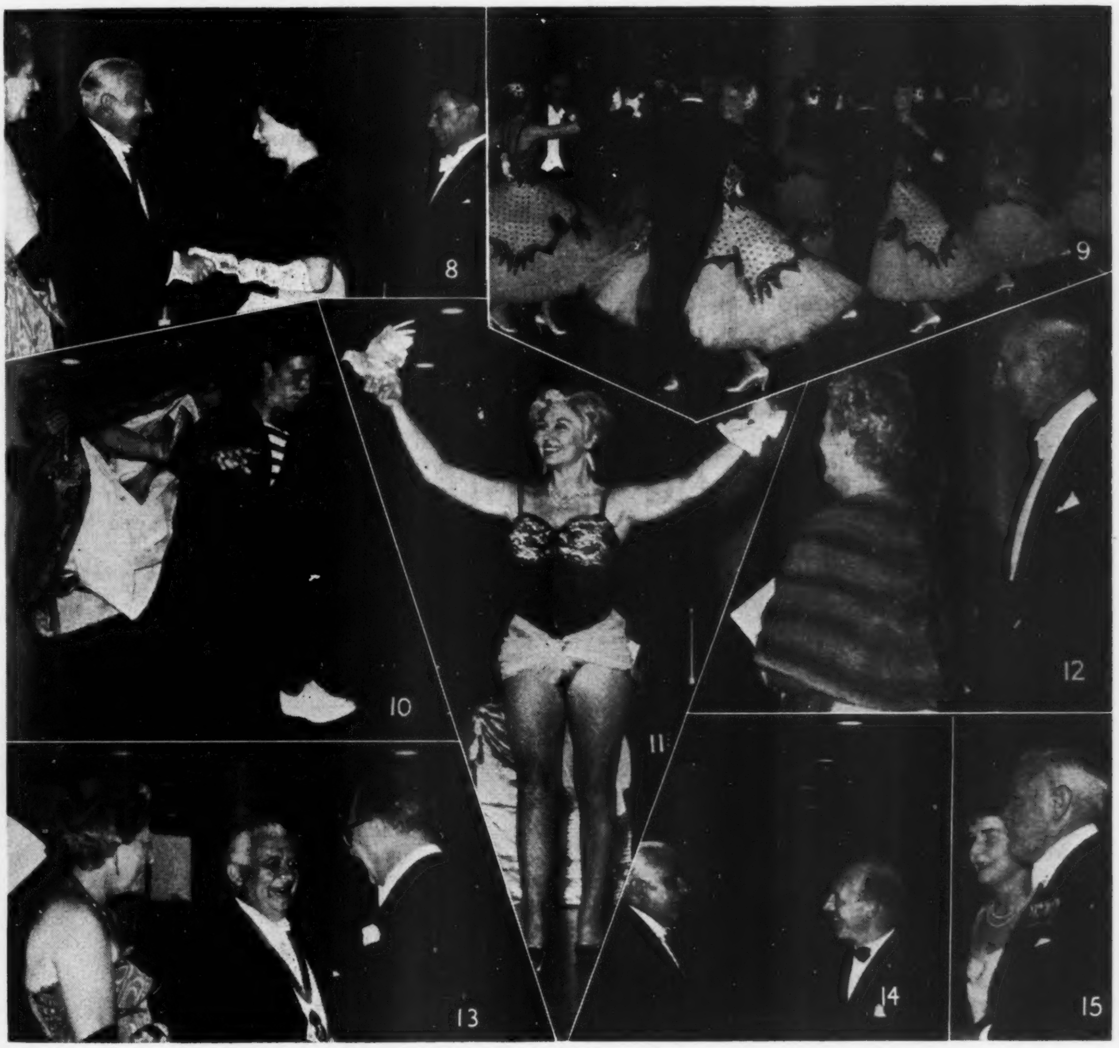


The Conversazione, which took place at the Royal Festival Hall, London, on Monday, 27th June last, was the first function of its kind to be arranged by The Institution of Production Engineers. Its success may be judged from the fact that at the end of the evening many of those present were expressing the hope that this would become a regular event in the Institution's calendar.

More than 500 members, their ladies and guests, were received by the President of the Institution, Mr. G. Ronald Pryor, and Mrs. Pryor. The Band of the Life Guards (2) under their Director of Music, Captain W. Jackson, A.R.C.M., p.s.m., played throughout the reception and gave a concert later in the evening, alternating with dancing to George Firestone and his Band.

Personalities being greeted by the President and Mrs. Pryor (left, above) are (1) Mr. R. H. S. Turner, Chairman of Council, and Mrs. Turner; (3) Mr. and Mrs. G. R. Blakely; (5) Sir Stanley Rawson, who earlier in the day had presented the 1960 Viscount Nuffield Paper to the Institution; (4) Mr. William Core, Past President of the London Section, and Mrs. Core. In (6) and (7) Mr. E. W. Hancock, O.B.E., Past President of

HALL, LONDON, 27th JUNE, 1960



the Institution (extreme right) and Mrs. Hancock (extreme left), and their party, are obviously relaxed and enjoying the evening.

The Cabaret, which was staged from 10.30 p.m. to 11 p.m., included (9) the Frank and Peggy Spencer Formation Dancers; (10) Beryl and Bobo, whose original presentation of their trampoline act met with rousing applause; and (11) June Merlin, "The Bewitching Witch".

Supper was served throughout the evening, and films of general interest were also shown during the evening, in the Recital Room.

Other photographs above show (8) the arrival of Sir Stanley and Lady Harley; (12) Sir Walter Puckey, Past President, and Lady Puckey; (13) Mr. J. C. N. Hughes, the Institution's Advertising Contractor, chatting with the President and Mrs. Pryor; (14) Mr. T. B. Worth, Head of the Department of Production Engineering, Birmingham College of Advanced Technology, with the President; and (15) Major-General K. C. Appleyard, C.B.E., Past President.

PRESIDENT ATTENDS PRIME MINISTER'S MEETING

Mr. G. Ronald Pryor, President of the Institution, was one of the 400 representatives of industry and commerce invited to attend the Prime Minister's meeting on 18th July, to mark the beginning of the Government's new export drive.

VISIT OF AUSTRALIAN PRESIDENT

His many friends in the United Kingdom have been pleased to renew acquaintaince with **Mr. J. M. Steer,** President of the Australian Council, who is visiting this country.

Mr. Steer attended the Meeting of Council held at Chesterfield Street on 21st July last, and gave a report on the development and progress of the Institution in Australia during his two-year period of office, which was just drawing to a close.

He said he was especially pleased to have had the opportunity of visiting the United Kingdom during his Presidency and in particular to have the honour of addressing the Council.

Mr. Steer, who is a past Secretary of the Birmingham Section of the Institution, also attended the Institution's Summer Meeting and Conversazione on 27th June.

THE STANDING COMMITTEES 1960 - 1961

The following members have been elected to serve on the Institution's Standing Committees for the year 1960 - 1961 :

Finance and General Purposes Committee

The Principal Officers:

The President: Mr. G. Ronald Pryor.
The Vice-President: Mr. H. Burke.
The Chairman of Council: Mr. R. H. S. Turner.
The Vice-Chairman of Council: Mr. A. L. Stuchbery.
The Immediate Past Chairman of Council: Mr. H. W. Bowen, O.B.E.

Elected Members:

G. R. Blakely	E. Percy Edwards	R. E. Leakey
W. H. Bowman	H. G. Gregory	G. A. J. Witton

The Chairmen of all Standing Committees — Editorial, Education, Hazleton Memorial Library, Membership, Papers, Research and Technical, and Standards — are ex-officio members of the Finance and General Purposes Committee.

Education Committee

The Principal Officers

W. G. Ainslie	A. A. Jacobsen	R. J. Sury
C. T. Butler	Dr. T. U. Matthew	E. Walshaw
J. A. W. Deboo	M. G. Page	C. A. Whitford
R. Dent	J. H. Perkins	T. B. Worth
K. J. Hume	E. Poole	

Membership Committee

The Principal Officers

A. Betts Brown	K. J. Hume	J. A. W. Styles
W. M. Buchan	E. G. Kinch	K. E. Taylor
G. H. Crump	T. F. Newton	R. Wheeler
R. Dent	R. D. Owen	B. Whittaker
E. Percy Edwards	H. Spencer Smith	

Editorial Committee

The Principal Officers

J. Mitford Brice	J. L. Gwyther	M. J. Sargeaunt
Dr. G. S. Brosan	W. F. Hilton	B. E. Stokes
E. N. Corlett	H. Peter Jost	
Dr. S. Eilon	J. C. Z. Martin	

Papers Committee

The Principal Officers

J. Mitford Brice	J. A. Grainger	G. Wittenberg
Dr. G. S. Brosan	A. J. Lawrance	C. C. Cornford
F. C. Cooke	J. C. Z. Martin	
A. A. J. Francis	R. E. Mills	

Research and Technical Committee

The Principal Officers

L. W. Bailey	Dr. S. Eilon	K. J. Hume
C. T. Butler	F. G. S. English	H. W. Mander
J. G. Collyear	R. M. Evans	S. G. E. Nash
G. Deane	R. Gore	J. G. Noble
Prof. N. A. Dudley	J. L. Gwyther	T. B. Worth

Standards Committee

The Principal Officers

N. A. Butterworth	R. E. Mills	H. Stafford
B. W. Charman	R. V. Rider	E. Steele
D. B. Ebsworth	B. A. J. Rule	J. H. Winskill
J. Harris	T. A. C. Sparling	W. E. Wright

Hazleton Memorial Library Committee

The Principal Officers

J. Aikman	H. L. Madeley	The Lord Sempill, A.F.C.
L. W. Bailey	R. V. Rider	
J. Isaacs	M. J. Sargeaunt	J. D. Smith

Materials Handling Group Activities

LONDON SECTION VISIT

AS a first step in arranging an active programme of events the London Section Group Committee arranged a visit to the Refrigerator and Cleaner Factories of Electrolux Ltd., which took place on 23rd June, 1960.

The party was met by Mr. G. Kelly, Superintendent of the Cleaner Factory, and also Chairman of the Institution's Luton Section. The party were conducted round the works by Mr. J. L. Blackbourn, Stores Superintendent.

It was interesting to learn that the Company consider that at the moment they can make bigger savings in costs by improving their handling than by concentrating on production methods.

The party were shown all aspects of handling and of particular interest was the handling of tube in the Goods Inwards Stores. The method of handling is that the tube is arranged in bundles and clamped into two "U" frames, pins having been welded to the side of the "U" frames, and these are located into horizontal slots of a cradle attached to the crane lifting tackle. By this means bundles of tube can be stacked to considerable heights and with the minimum of effort. This type of handling, however, requires close liaison with the supplier, as the tubes are packed in this manner at the moment of manufacture.

A scheme of palletisation is being undertaken for all small parts and considerable use is being made of fork lift and reach trucks. Trucks were also used for the changing of diesets to facilitate tool changes. Considerable use is also made of conveyors, not only for handling but also for live storage.

The London Section Group Committee, at a recent meeting, discussed the question of further visits and feel that these can be of considerable value, not only to the visitors but also to the host firm if a certain

Above: Fitting insulation into completed absorption units.

Left: Steel tubing store — stillages of steel tubing cut to the length required for use are moved direct from the store to the cooling unit shop beyond, by a gantry crane.

amount of planning is undertaken beforehand. It is proposed that each member of the Group making the visit will be asked to note certain aspects of the handling taking place and in this way a more comprehensive report can be compiled, which should be of considerable value.

Further information regarding the activities of the London Section Materials Handling Group may be obtained from :

MR. I. KING (Technical Officer),
10 CHESTERFIELD STREET,
MAYFAIR, LONDON, W.1.

BIRMINGHAM SECTION VISIT

A VISIT to Messrs. Hardy Spicers Ltd. was made by members of the Birmingham Section together with visitors from Sheffield and Brighton on 25th May, 1960, to investigate the handling systems installed by the country's largest manufacturer of transmission units. These units are made for automobiles, agricultural machines and shipping gear.

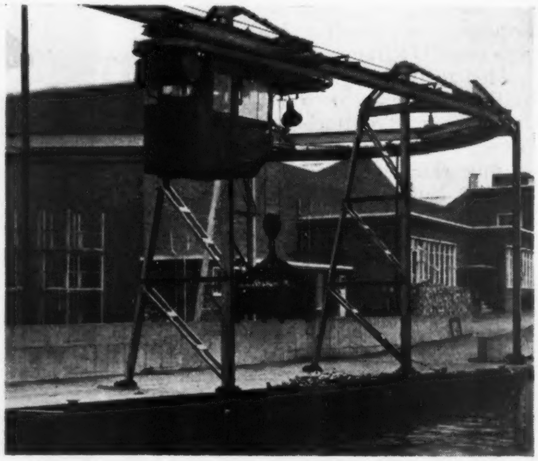
The party was shown all aspects of the handling from the receipt of raw material, mainly in the form of rough forgings and tube, to the dispatch of finished assemblies. It was interesting to note that the forgings, which are produced by an associate company within the Birfield Group, are shipped by barge and the layout of the Hardy Spicer factory was planned so that the forging store was located beside the canal, in order that this extremely cheap form of transport could be used with the minimum of internal handling.

For the final inspection and assembly of needle bearings and cups an interesting layout has been conceived, extensive use being made of vibratory feeders. The operations of inspection, grading and assembly are completely automatic.

The visit concluded with a tour of the tube mill, fabricating, straightening, balancing and dispatch departments.

Further information regarding the activities of the Birmingham Section Materials Handling Group may be obtained from :

MR. R. C. SHORT, Grad.I.Prod.E.
41 WITHERFORD CROFT,
BLOSSOMFIELD, SOLIHULL,
WARWICKSHIRE.



Above : Delivery of forgings by barge.

Left: A photograph showing the extensive use of vibratory feeders.

YORKSHIRE SECTION DINNER

The photograph shows (from left to right): Sir Donald Kaberry, Bart., T.D., M.P.,; Mr. R. Shlton, Section Chairman; The Lord Mayor of Leeds (Alderman Mrs. G. Stevenson, J.P.); and the President of the Institution, Mr. G. Ronald Pryor.

THE Annual Dinner of the Yorkshire Section of the Institution, which took place at the Griffin Hotel, Leeds, on 30th April last, was as usual a well-organised and much-enjoyed affair.

The toast to "The Leeds Section" was proposed by Mr. E. Yorke-Saville, Chairman and Managing Director of British Jeffrey-Diamond Ltd., who paid generous tribute to the skill and versatility of the production engineer, and his vital importance to the national economy.

Referring to the intensive competition in industry, both at home and overseas, Mr. Yorke-Saville stressed the urgent need for substantial investment in the most modern capital equipment. "No man", he said, "and certainly not a production specialist, can give of his best without the proper tools for doing the job. I would like to stress, with all the emphasis at my command, the absolute necessity of keeping our factories right up-to-date. This entails a continuous process of modernisation and investment. Naturally, such a policy costs a great deal of money, and it is here that the Government can play a most worthy part, by creating a courageous and well-inspired write-off policy for industry — if nothing more."

"The present arrangements", concluded Mr. Yorke-Saville, "are totally unrealistic and inadequate in this age of rapid development and intense foreign competition."

DIARY FOR 1960

SEPTEMBER 17 ... ... **Fourth Graduate and Student Convention,** Birmingham (see Supplement).

SEPTEMBER 21 ... ... **The 1960 E. W. Hancock Paper,** in London (see Supplement).
Speaker : **John Marsh, Director, Industrial Welfare Society.**
Subject : **"The Cult of the Self-Made Man."**

OCTOBER 12 - 14 ... ... **National Conference,** at Brighton.
Theme : **"Modern Trends in the Manipulation of Metals"** (see enclosed pamphlet).

NOVEMBER 2 ... ... **Annual Dinner,** at the Dorchester Hotel, London.

NOVEMBER 10 ... ... **The 1960 Sir Alfred Herbert Paper,** at The Royal Institution, London.

news of members

Mr. E. W. Hancock, O.B.E., Honorary Member and Past President, has retired from Humber Limited, having reached retiring age. He has been associated with the motor industry for nearly 50 years. He first joined the Humber Company as Works Manager, in 1935, and rejoined the firm in 1948 as Director and General Manager, after a five-year period as General Manager at Messrs. Rubery Owen Ltd., Darlaston. Mr. Hancock first went to Coventry in 1928 when he was Works Manager of Daimler Limited; two years later he was Works Manager of both Daimler and B.S.A. Ltd., Small Heath, Birmingham.

For the past 18 months he has operated as Director of Special Projects for the Manufacturing Division of the Rootes Group, and also as a Director of Humber Limited. It is understood that Mr. Hancock is not completely retiring from industry, and after a holiday he will be undertaking consulting work in the field of production engineering, including industrial relations.

Mr. C. Sumner, Member, has been appointed Plant Manager to A.C.-Delco, No. 2 Plant, Southampton. Mr. Sumner is Chairman of the Southampton Section, and Southern Regional Chairman.

Mr. R. E. Mills, Member, has been appointed Chief Designer of S. E. Opperman Limited. Mr. Mills is a member of the Papers and Standards Committees of the Institution, and Immediate Past Chairman of the Research and Technical Committee.

Mr. J. B. Webster, Member, Works Manager of Crane Limited, has recently been appointed a Director of the Company.

Mr. R. W. Hillyer, Associate Member, has relinquished his position as Works Manager with Dyson & Co. (Enfield) 1919 Ltd., Bletchley, and has taken up a new appointment with Associated Transistors Ltd., Ruislip. After a short induction period as Senior Project Engineer, Mr. Hillyer will take up duty as Resident Engineer (U.S.A.) in liaison with the Radio Corporation of America, Summerville, New Jersey.

Mr. W. H. Landmann, Associate Member, formerly Performance Engineer with Charles Colston Ltd., of High Wycombe, has now taken up an appointment as Factory Manager with the Square Grip Reinforcement Co. Ltd.

Mr. K. Liquorish, Associate Member, has been awarded the City and Guilds of London Institute Insignia Award in Technology. Mr. Liquorish is Honorary Secretary of the Nottingham Section.

Mr. James Hartley, Associate Member, has relinquished his position as Lecturer in Mechanical Engineering at Bishop Auckland Technical College, and has taken up an appointment as Lecturer in Mechanical Engineering at Blackpool Technical College and School of Arts.

Mr. Paul S. McCaig, Associate Member, formerly Sales Engineer with Ex-Cell-O Corporation of Canada Limited, has recently been appointed Export Sales Engineer with Ex-Cell-O Corporation, in Detroit, Michigan, U.S.A.

Mr. R. E. Patience, Associate Member, has relinquished his position with Simplex Electric Co. Ltd., Oldbury, Birmingham, to take up an appointment as Development Engineer with Messrs. I.C.I. (Hyde) Limited, Coventry.

Mr. D. H. Sheret, Associate Member, has now taken up the appointment of Superintendent of Production at Rolls-Royce Ltd., nr. Loughborough, Leics. Mr. Sheret was at one time a Corresponding Member of the Papers Committee.

Mr. L. Walmsley, Associate Member, has recently relinquished his position with Winthrop Laboratories Ltd., and has taken up an appointment as Production Engineer with Messrs. Bailey (Malta) Ltd., Malta.

Mr. W. H. Baugh, Graduate, has taken up the appointment of Works Engineer to Messrs. Ductile Planetary Mill Ltd., Wednesfield.

Mr. J. D. Bendall, Graduate, has relinquished his position with Bristol Aircraft Ltd., and is now Plant Layout Engineer with Audley Engineering Co. Ltd., Newport, Shropshire.

Mr. K. Popple, Graduate, has recently taken up an appointment as a Design and Development Engineer with Rubery Owen & Co. Ltd., Engine Development Division, Bourne, Lincs.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

Anvoner, S. "**Solutions of Problems in the Theory of Machines.**" *London, Pitman,* 1959. 492 *pages. Diagrams.* 35s.

Intended for students working for the H.N.C. in engineering, the Diploma in Technology, and engineering degrees of London University. The book contains 488 examples of which 203 are fully worked out, and the remainder left as exercises for which answers are provided. At the beginning of most chapters the relevant formulae have been deduced for reference purposes. Most of the examples are taken from past London University examination papers.

Contents:- Linear and angular motion — Energy, momentum and impulse — Friction — Governors — Gyroscopic couple and precession — Velocity and acceleration diagrams, inertia torque — Turning moment diagrams — Gears — Epicyclic gears — Vibrations — Balancing — Cams.

Booth, Andrew D. *Editor.* "**Progress in Automation.**" Volume 1. *London, Butterworths Scientific Publications,* 1960. 230 *pages. Diagrams.* 42s.

This is the first of a series of volumes, which will appear from time to time, and in which it is hoped that national, international and specialized aspects of the subject will be covered. This volume, is, in a sense, devoted to progress made in Great Britain. The 11 Papers, by specialists in the various fields, are divided into three groups: an historical introduction; a section on techniques; and a section on automatic control systems.

Contents:- *Introduction*: (Andrew D. Booth, Reader in Computational Methods, University of London.) — *Methods*: Analogue to digital conversion techniques (G. T. Herring, Principal Scientific Officer, Royal Aircraft Establishment, Farnborough, Hampshire.) — Application of electronics to process control systems (J. M. Keating, Senior Control Engineer, British Petroleum Company.) — A basic system of position control for the traversing tables of machine tools. (K. J. Coppin, Senior Design Engineer, Machine Tool Control, EKCO Electronics Ltd.) — The Inductosyn. (H. J. Finden, Manager, the Plessy Company, Electronic Research Laboratories.) — The use of nucleonic gauges in automatic schemes. (T. B. Rowley, Head of Applications, Isotope Developments Ltd.) — Nucleonic methods of fluid density measurement. (A. E. M. Hodgson, Applications Laboratory, EKCO Electronics Ltd.)—*Applications*: The Ferranti system of machine tool control. (D. T. N. Williamson, Head of Machine Tool Control Department, Ferranti Ltd.) — The E.M.I. system of machine tool control. (F. W. Hartley, Industrial Division, E.M.I. Electronics Ltd.) — Automatic control in the manufacture of steel strip. (G. Syke, Head of Development and Research, Baldwin Industrial Controls.) — Automatic Inspection. (John A. Sargrove, Consulting Engineer.)

British Institute of Management, London. "**The Cost of Labour Turnover.**" *London, the Institute,* 1959. 79 *pages.* 17s. 6d.

Describes the results of investigations into the financial effects of labour turnover in 16 companies. The cost of turnover is usually hidden, and it does not appear in company cost or financial accounts, yet these investigations suggest that in some companies, "invisible" outgoings of 10s. 0d. a week or more per worker are involved. The pamphlet presents the B.I.M. method of costing labour turnover, and compares it with other cost formulae.

British Non-Ferrous Metals Association, Sheffield. "**Better Platings on Die Castings: Interim Report.**" *London, the Association, January,* 1960. 18 *pages. Illustrated. Diagrams.* (Development Report No. 62.)

The results of investigations into the chromium plating of zinc-alloy die castings. Results of experiments seem to indicate that in spite of difficulties in depositing, there are considerable benefits to be obtained from applying thicker than usual chromium deposits over the usual bright nickel deposits.

Buchan, S. "**Rubber to Metal Bonding.**" 2nd Edition. (Revised) *London, Crosby Lockwood,* 1959. 300 *pages. Illustrated. Diagrams.* 42s. 0d.

A comprehensive and detailed account of the science and techniques of bonding natural and synthetic rubber to metals. The first edition was published in 1948. This edition has been substantially revised and brought up to date. In his preface the author states that as much as other processes he has emphasised the brass plating bonding process, since it is still generally used, and is the one by which newer processes are measured and judged.

Contents:- Introduction — Plating plant — Cleaning solutions — Brass plating solutions — Methods of analysis — Electro plating — Processing and process control — Natural rubber compounding — Synthetic rubber compounding — Moulds and moulding — Physical examination of brass deposits — Chemical examination of the rubber to brass bond — Properties of the rubber to brass bond — Bonding agents, thermoplastic — Bonding agents, Halogenated rubber derivatives — Bonding agents, the polyiscocyanates — Bonding agents, various — Bonding vulcanised rubbers — Testing bonded units — The nature of the rubber to metal bond — The importance of design — Appendix. Table of proprietary materials, their composition, function and supplier — Bibliography.

Canada, National Research Council, Technical Information Service. **"Foundry Sand Reclamation."** *Ottawa, the Council,* 1959. 7 *pages. Mimeo.* (T.I.S. Report No. 59.)

A survey of information available and an annotated bibliography.

Fraser, John Munro. **"Human Relations in a Fully Employed Democracy."** *London, Pitman,* 1960. 352 *pages. Diagrams.* 30s. 0d.

Twentieth-century industrialists and managers cannot, as their predecessors did, rely upon a plentiful supply of raw materials and a docile labour force. This fact has led to the professionalisation of management to the development of special techniques for the economic utilisation of labour and materials, and to the study (and rediscovery) of "human relations", a term, which, in the words of the author, is used broadly to denote those aspects of management which affect people as people during working hours. This book, based upon lectures delivered at Birmingham College of Advanced Technology, at which the author is Reader in Human Relations, provides a framework of coherent theory with which to interpret human personality and social interaction. It examines working human beings in their social, psychological and economic environment, in relation to managerial problems and duties. A feature of the book which will be particularly useful to students are the notes at the end of each chapter, which provide a summary of the contents.

Contents:- The problem before us — The aims of human relations training — *Section* 1. *Interpretation of the outside world.* Behaviourist man and the stimulus response bonds — The additions of meaning to sense impressions—The development of thought—Concepts of human life — *Section* 2. *Human aims and purposes and their means of satisfaction.* Basic needs and their satisfaction — The motive power behind our various activities — Attitudes and the satisfaction of needs — Emotions and the adjustment to pressures — Implications for management — *Section* 3. *Social and group life.* Our present way of life and its contrasts — Processes at work in a social group — Social roles — Social groupings and organisation — The social psychology of communication and control — Sources of strength and weakness in organisation — *Section* 4. *Contemporary problems in human relations.* The present way of life — The economic background.

Miller, G. L. **"Tantalum and Niobium."** *London, Butterworth's Scientific Publications,* 1959. 767 *pages. Illustrated. Diagrams. Tables.* 120s. 0d. (Metallurgy of the Rarer Metals Series.)

This volums in the series "Metallurgy of the Rarer Metals" follows the same pattern as the first five. It is a detailed survey of available chemical and metallurgical information about tantalum and its sister metal noibium (or columbium).

Contents:- History and occurrence — Consumption and uses — Extraction of tantalum and niobium from their ores — Separation of tantalum and niobium and their purification — Production of tantalum and niobium — Consolidation — Fabrication (work hardening, annealing, forging, sheet rolling, rod rolling and swaging, wire drawing, tube production, presswork and spinning, machining, riveting, welding, brazing and soldering, electroplating other metals on niobium — Physical and structural properties — Corrosion by chemicals, gases and liquid metals — Binary alloy systems — Chemical analysis — Metallographic techniques for tantalum and its alloys — Selected thermodynamic data for compounds of tantalum and niobium.

Moritz, Robert Edouard. **"On Mathematics and Mathematicians (formerly titled : Memorabila Mathematica or the Philomaths Quotation Book.)"** *New York, Dover Publications; London, Constable,* 1958. 410 *pages.* 16s. 0d.

This book was orginally published in 1914. It comprises a collection of over 1,400 quotations divided into 21 chapters dealing *int. al.* with arithmetic, algebra, geometry, the philosophy and logic of mathematics, and anecdotes about mathematicians.

Morris, J. Walker. **"Job Evaluation."** *Birmingham, Industrial Administration Group of the Guild of Students of Birmingham College of Technology, and the Institute of Industrial Supervisors,* 1960. 43 *pages. Tables.* 3s. 0d.

A step-by-step account of the operation of two of the most commonly used systems of job evaluation: the factor comparison system and the weighted points system. The book is directed primarily to foremen, and other supervisory staff, but should be useful to others.

Waring, A. B. **"People and Productivity : A Practical Guide for Administrators."** *London, British Productivity Council,* 1959. 95 *pages. Illustrated. Diagrams. Specimen forms.* 25s. 0d.

The object of this book is to provide a practical guide to some of the methods by which good "human relations" can be established in a factory, and to how these can be used to increase productivity.

Contents:- Factory competitions — Workpeople's production committees — Workpeople's suggestion schemes — Support for the foreman.

Wernick, S. and Pinner, R. **"The Surface Treatment and Finishing of Aluminium and its Alloys."** 2nd Edition. *Teddington, Middlesex, Robert Draper,* 1959. 607 *pages. Illustrated. Diagrams. Tables.* 90s. 0d.

An attempt to bring under one cover detailed descriptions and discussions of all the processes available for the surface treatment and finishing of aluminium and its alloys. The first edition was published in 1956, and was based on a series of articles which appeared in *Sheet Metal Industries.* This, the second, has been thoroughly revised and much new material added including information about recent types of chemical polishing solutions used in Europe and the U.S.A.; new developments in the control of anodising processes, and new tests for finished aluminium. Data on all alloys and dyestuffs has been brought up-to-date.

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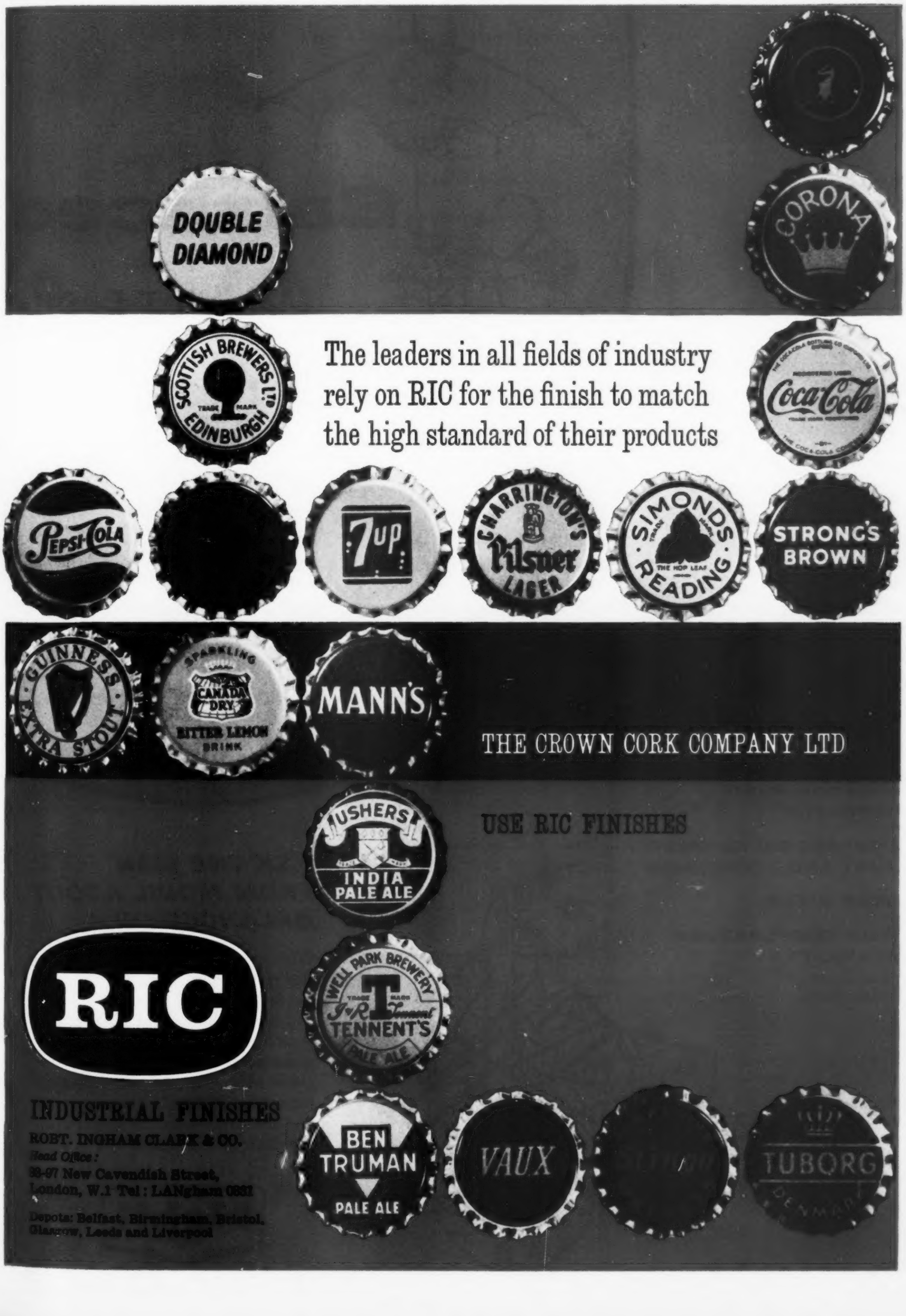
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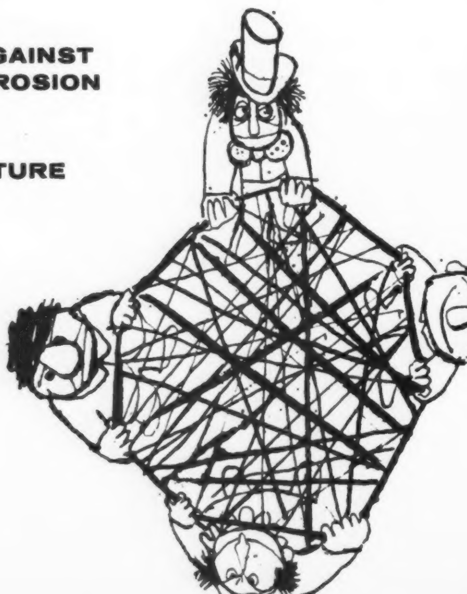

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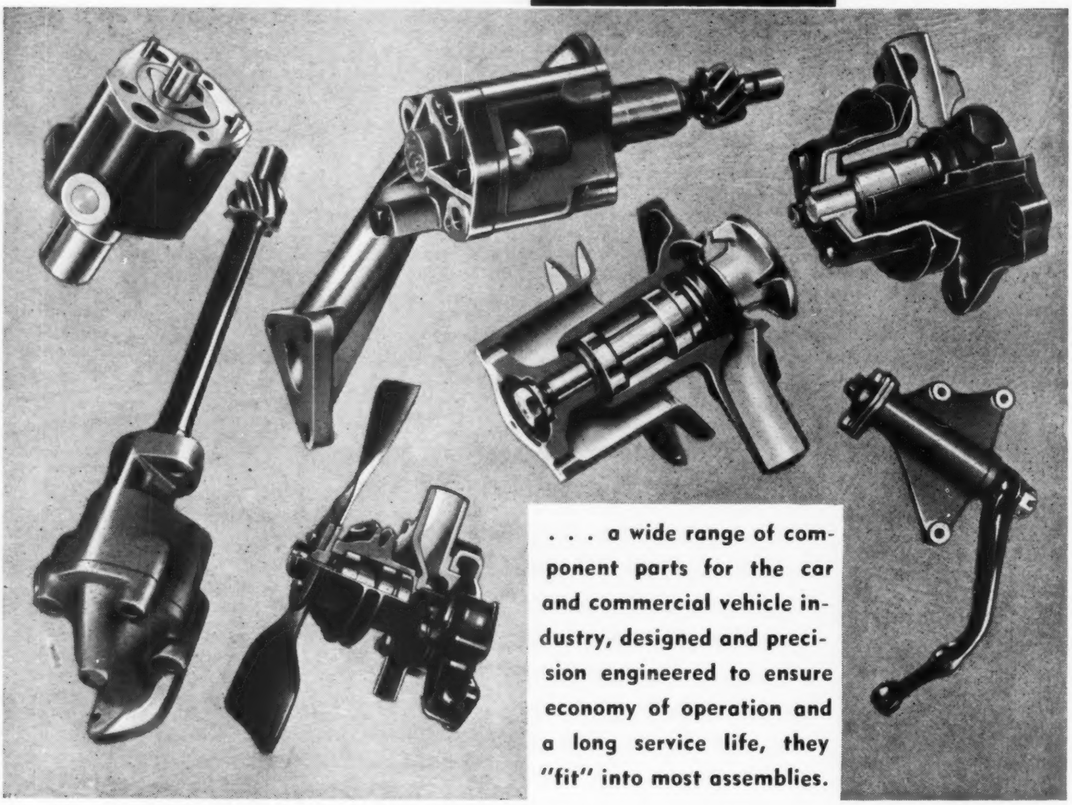

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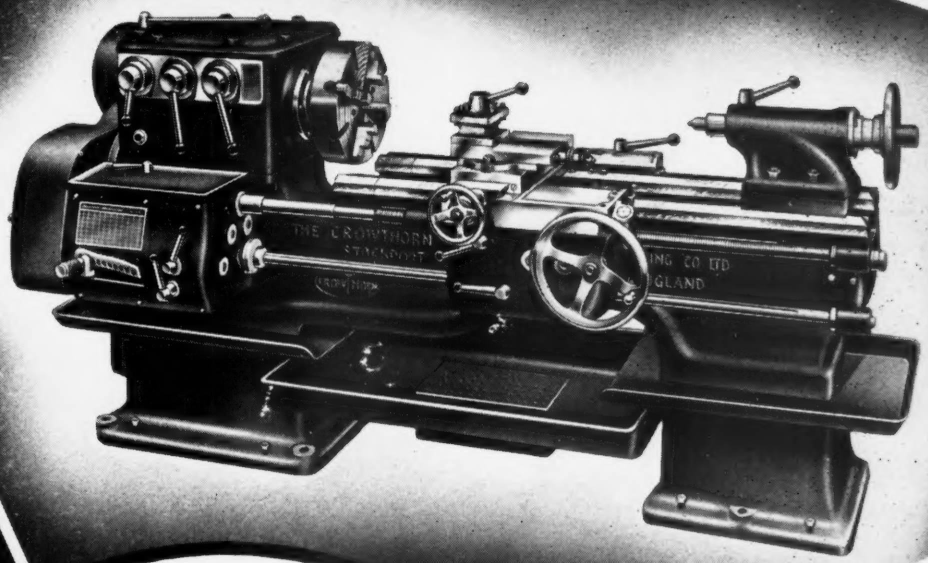

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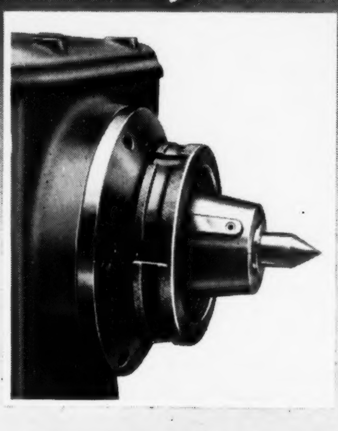

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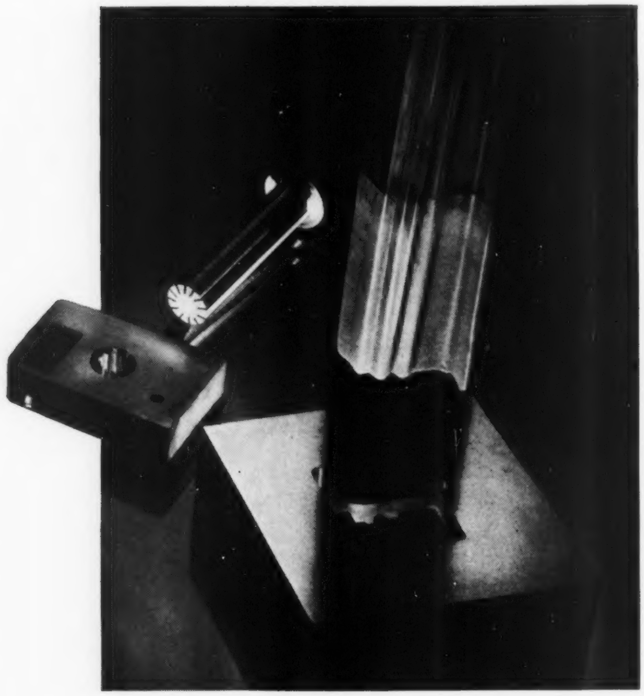

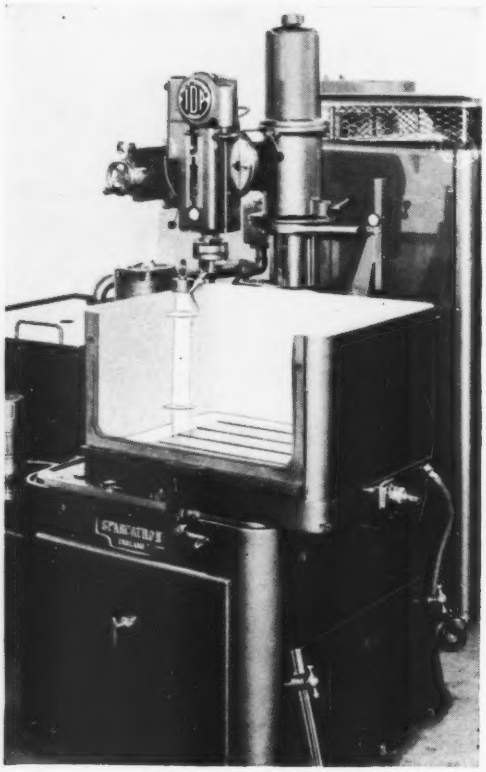

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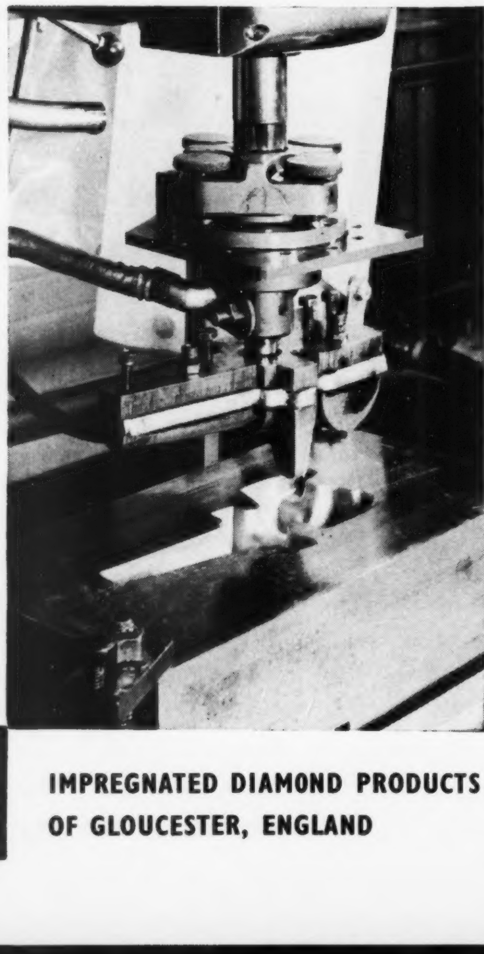

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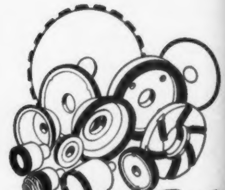

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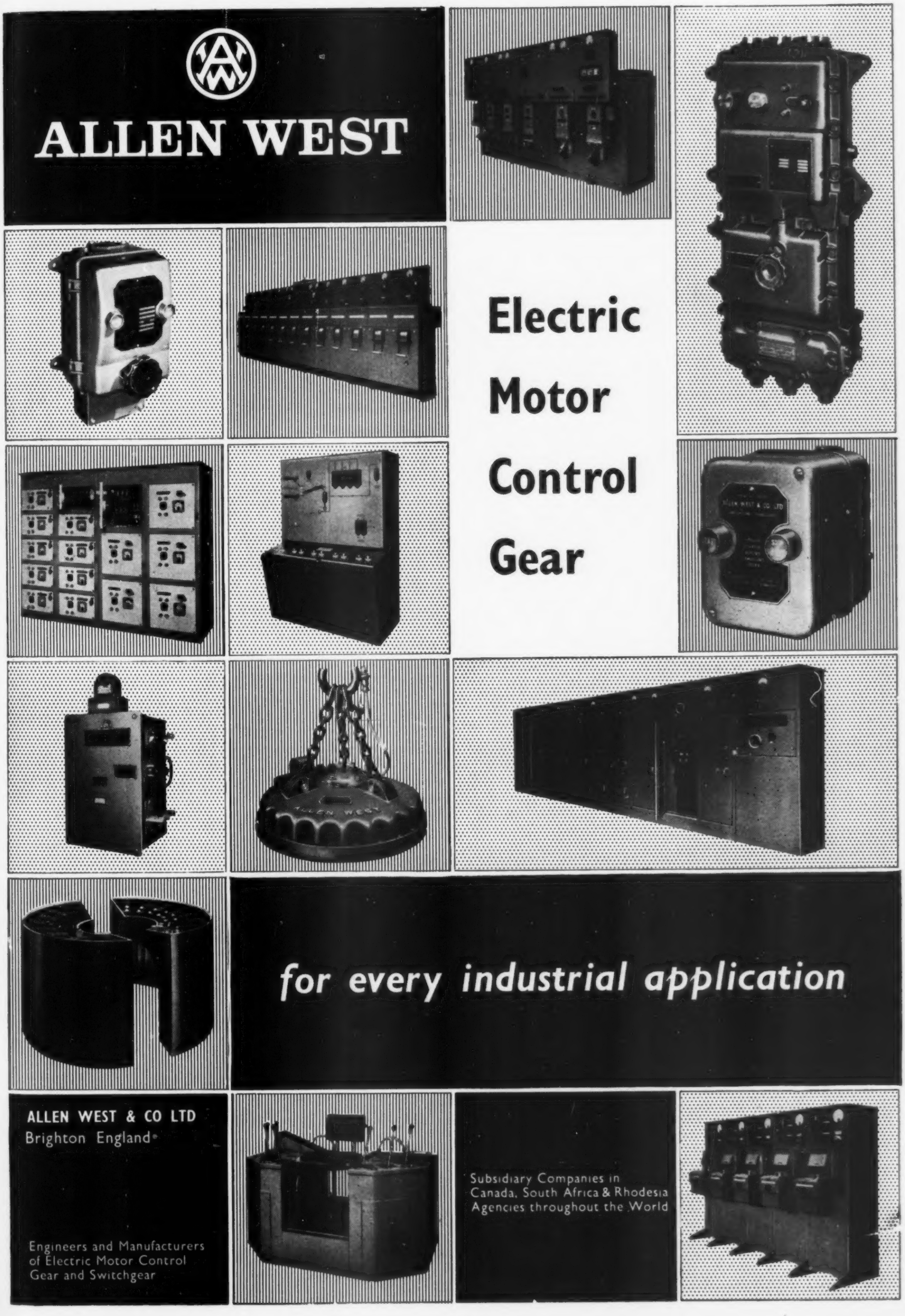
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for every industrial application
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Subsidiary Companies in
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Agencies throughout the World

Another addition to the PYE Range of Induction Heaters

INDUCTION HEATING UNITS

These 6 kW induction heaters have been designed for continuous operation and incorporate the latest design techniques. The generators are of medium impedance output being suitable for general purpose heating applications such as annealing, brazing, hard and soft soldering, hardening and tempering. The availability of a high work coil kVA in association with multi-turn coils permit the heating of a wide range of ferrous and non-ferrous loads.

The oscillator value may be either air cooled (Type R.F. 3/A) or water cooled (Type R.F. 3/W) depending upon customer requirements. With the R.F. 3/A water is used only for cooling the tank and work coils. In the case of the R.F. 3/W a common water supply is employed for cooling the oscillator valve, tank and work coils.

Due to the simplicity of operation unskilled labour may be employed enabling production costs to be reduced. The controls, indicator lamps, anode current meter and process timer are conveniently grouped on the front panel. Compact design allows the equipments to occupy the minimum of floor space. The equipments in operation are extremely dependable as a result of advanced design and the use of components of proved reliability.

PYE PROCESS HEATING

FREE TECHNICAL ADVICE *is offered on the applications of R.F. heating to Tempering, Brazing and Hardening processes etc. Our technical representatives are at your service, or we will send you full details—please tick the appropriate box in the coupon.*

PYE LTD. PROCESS HEATING DIVISION
Telephone: CAMBRIDGE 57590

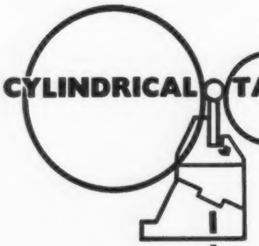
To Pye Ltd. Process Heating Division, 28 James Street, Cambridge
Please send me details of Pye Process Heating Equipment.

NAME ....

COMPANY ....

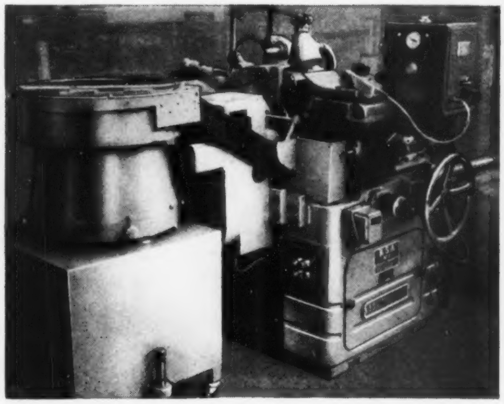
ADDRESS .... IPE 9

Please ask your Technical Representative to telephone for an appointment ☐ *Please send me full details* ☐



PLAIN CYLINDRICAL · TAPER · SHOULDER · SPECIAL · FORM · MULTI-DIAMETER

work ground on B.S.A. centreless grinders has an excellent finish and a high degree of diametrical and cylindrical accuracy



No. 4 machine equipped for automatic sizing-control and automatic infeed. Vibratory type hopper. Special bolts 7/16" × 2⅞"(11 mm × 73 mm) long are ground to a tolerance of 0.0005"(0.012 mm) Production : 700 bolts per hour. Sizing-control incorporates automatic grinding wheel head feed-compensation.

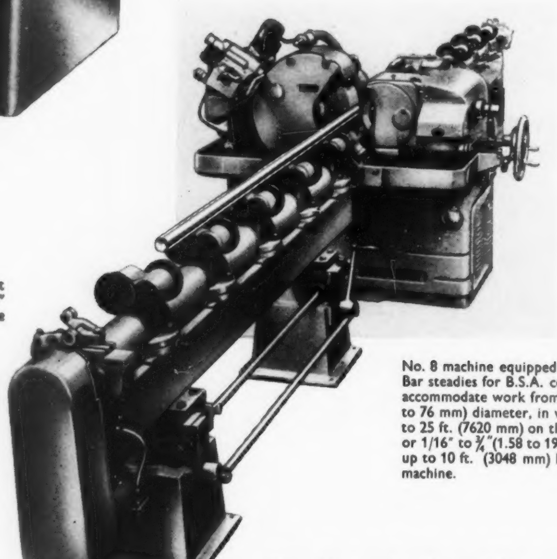
No. 4 MACHINE

Work diameter :	1/16"* to 3" (1.58 to 76 mm)
Grinding wheel Speed :	1270 rpm
Control wheel Speeds :	4
Width of wheels :	4" (101 mm) or 5" (127 mm)
Main motor :	10 h.p.

*(With special equipment work down to 0.010" (0.254 mm) dia. can be accommodated).

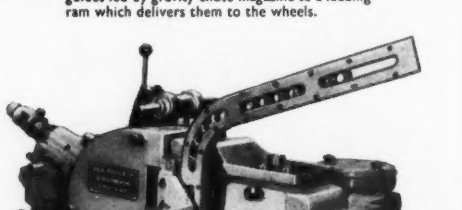
No. 8 MACHINE

Work diameter :	⅛" to 6½" (3.17 to 167 mm)
Grinding Wheel Speed :	1180 rpm
Control Wheel Speeds :	12
Width of Wheels :	5" (127 mm) or 8" (203 mm)
Main Motor :	20 or 40 h.p.



No. 8 machine equipped for bar grinding. Bar steadies for B.S.A. centreless grinders accommodate work from 1/16" to 3" (1.58 to 76 mm) diameter, in various lengths up to 25 ft. (7620 mm) on the No. 8 machine, or 1/16" to ¾"(1.58 to 19.05 mm) diameter up to 10 ft. (3048 mm) long on the No. 4 machine.

Below. No. 4 machine plunge grinding tappet guides fed by gravity chute magazine to a loading ram which delivers them to the wheels.



B·S·A

centreless grinders

B.S.A. TOOLS LIMITED BIRMINGHAM 33 ENGLAND

Agents in U.K., Burton Griffiths & Co. Ltd., Kitts Green, Birmingham 33.

STECHFORD 3071

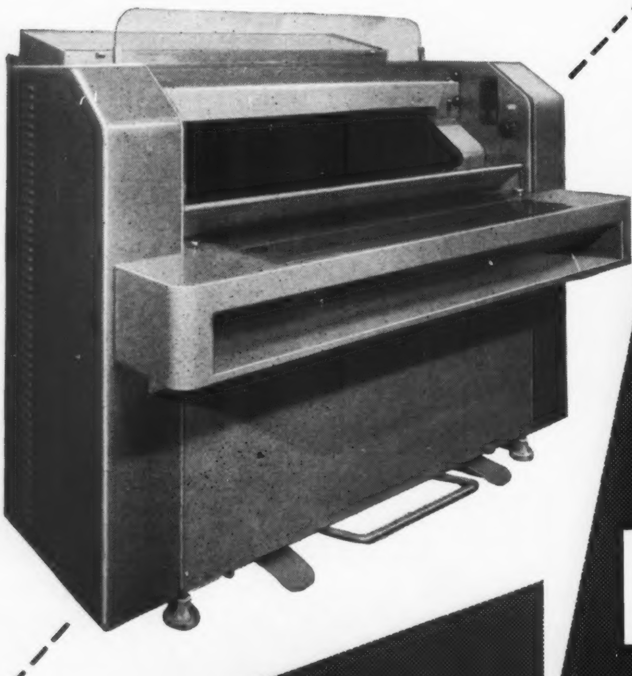
Rapid,

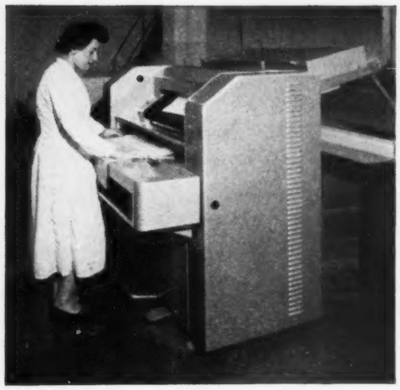
high-quality

photoprinting

and no ventilating system required

The Ilford AZOFLEX Model 246 Combine printing and developing machine (formerly known as Model 46/35) is designed for use in the print room of the large drawing office. It does not produce unpleasant fumes and special ventilating systems are thus unnecessary, making it a simple matter to move the machine to a new position at any time.





- Exposure, development and print delivery synchronized for simplicity of operation.
- All controls conveniently located for rapid, effortless adjustment.
- Pneumatic-assisted handling of originals and sensitised material to obviate fatigue.
- Complete design co-ordinated for exceptionally high potential output.
- Excellent mechanical layout giving silent, vibrationless running.
- Comprehensive maintenance service available at nominal cost.

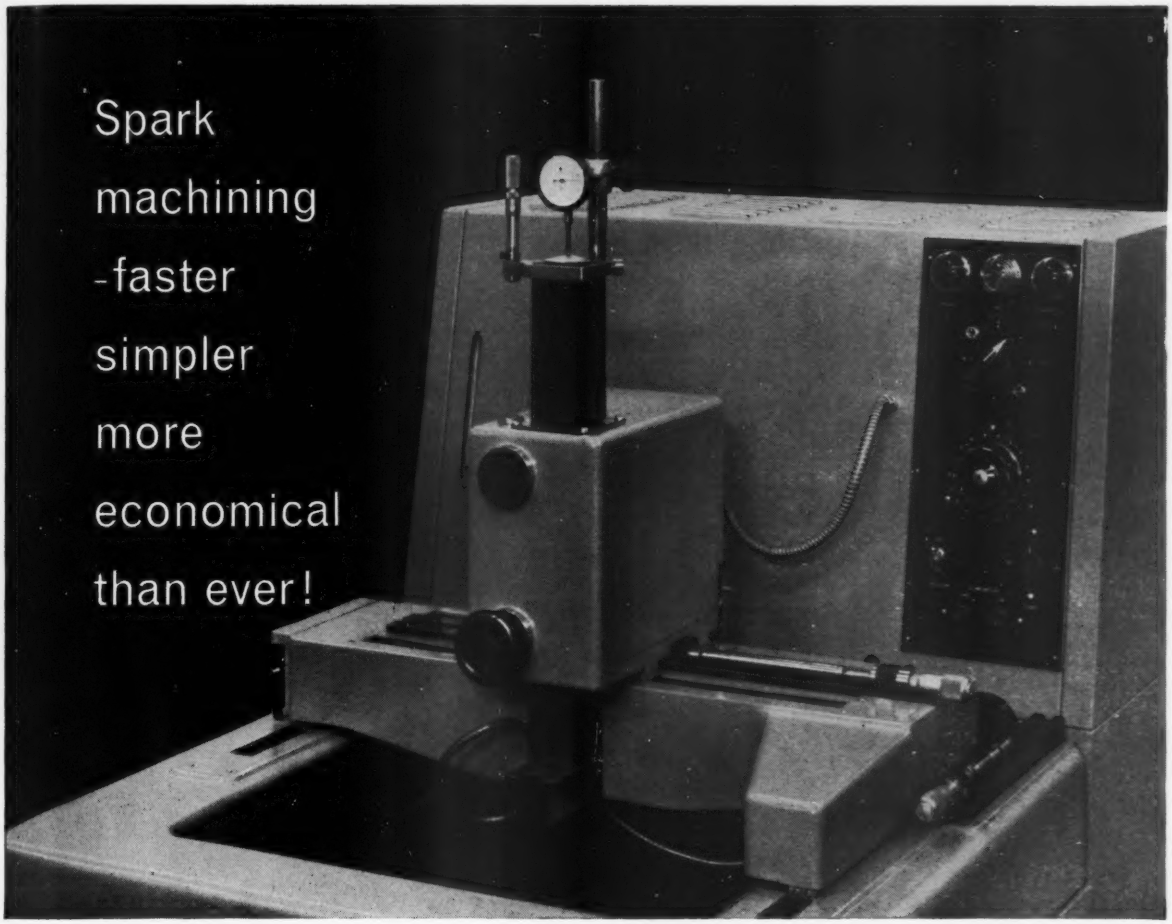
Capacity: rolls and cut sheets up to 42 in. wide.
Printing speed: from 2 ft. to 30 ft. per minute.
Lamp: H.P.M.V. quartz, 3,000 watt.
Dimensions: height, 58 in., width, 72 in., depth (tray extended) 80 in. Weight : approx. 1,400 lb.

Subject to certain conditions, the majority of AZOFLEX photoprinting machines can be hired as an alternative to outright purchase.

ILFORD *Azoflex*

PHOTOPRINTING MACHINES & MATERIALS

Full details from
ILFORD LIMITED, INDUSTRIAL SALES DEPT. AZ18M
ILFORD, ESSEX. TELEPHONE: ILFord 3000



The GKN Spark Machine
is faster, more accurate, more versatile

The GKN Spark Machine (Models B1 and B2) gives higher cutting rates, greater accuracy, and—on the B2 machine—a wider range of surface finishes than ever before.

It has all these outstanding features

Both models have a co-ordinate slide movement for rapid electrode positioning; an accurate depth stop; a dial gauge to show forward movement; an alternative work-table for extra paraffin depth.

It is compact and economical

The GKN Spark Machine is well-made, sturdy and compact. All parts of it—work head, electrical equipment and paraffin system—are mounted in the same cabinet. Yet with all these advantages, installation and running costs are low.

You should know more about it

Whether you are engaged in forging, wire-drawing or press-tool making, the GKN Spark Machine is something you should know about.

Write to our Sales Agents for the new brochure on the GKN Spark Machine

Manufactured by
WELSH METAL INDUSTRIES LTD., Caerphilly, Glamorganshire

Sales Agents U.K. M. C. Layton Limited,
Abbey Wharf Mount Pleasant, Alperton, Wembley, Middx
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GKN
spark
machine

DESIGNED BY THE
GKN GROUP RESEARCH
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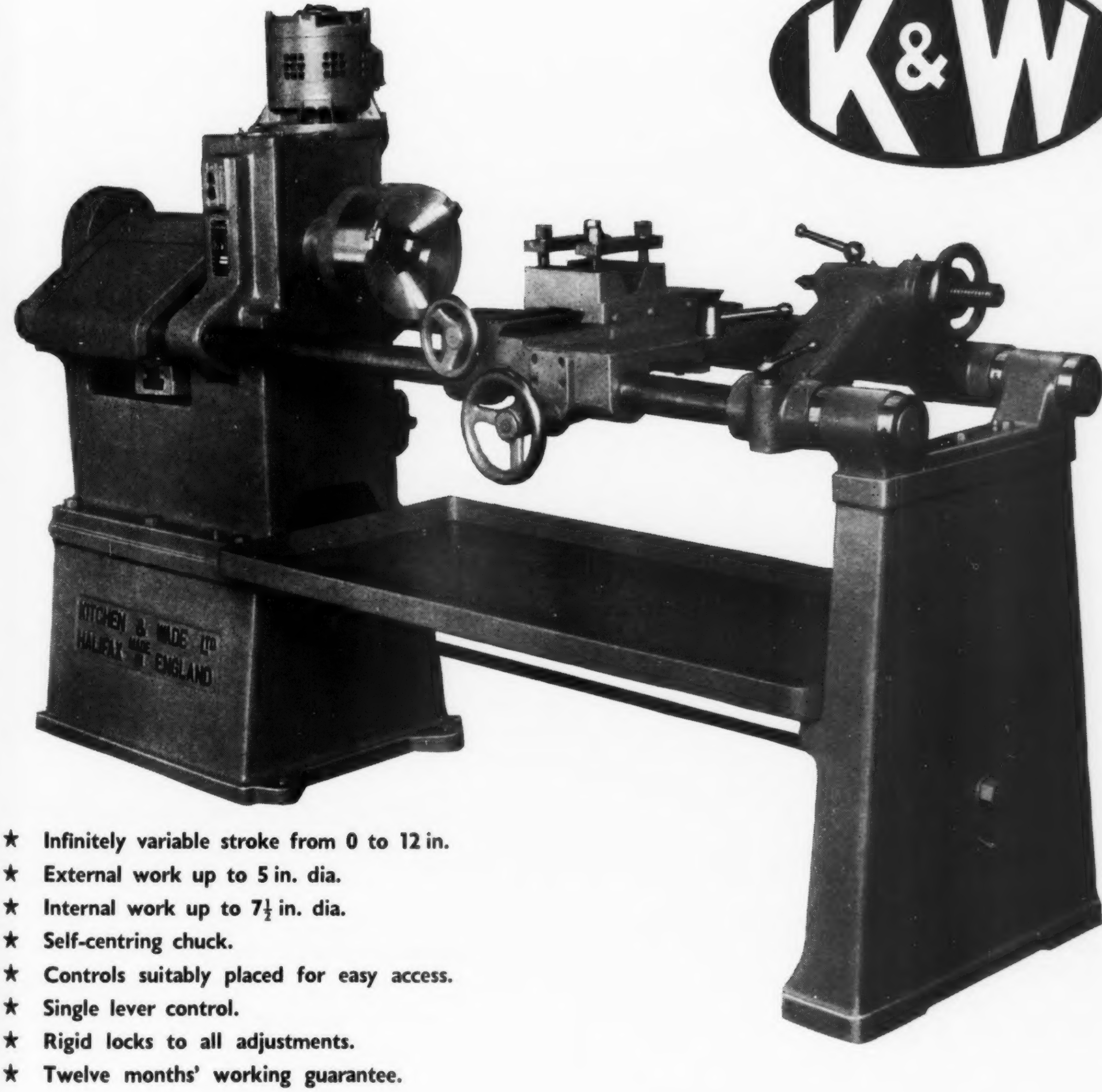
It pays to put OIL GROOVING on this simple machine designed for the job

K&W



- ★ Infinitely variable stroke from 0 to 12 in.
- ★ External work up to 5 in. dia.
- ★ Internal work up to 7½ in. dia.
- ★ Self-centring chuck.
- ★ Controls suitably placed for easy access.
- ★ Single lever control.
- ★ Rigid locks to all adjustments.
- ★ Twelve months' working guarantee.

A crank, driven by a train of gears from the spindle, actuates the oscillating stroke of the saddle. A spiral groove is cut over one circumference on one half of the oscillation and back over one circumference on the second half of the oscillation, making a figure of eight. The stroke can be disengaged by hand lever enabling ring grooves to be cut. Write today for a catalogue describing this economic machine for oil grooving work.

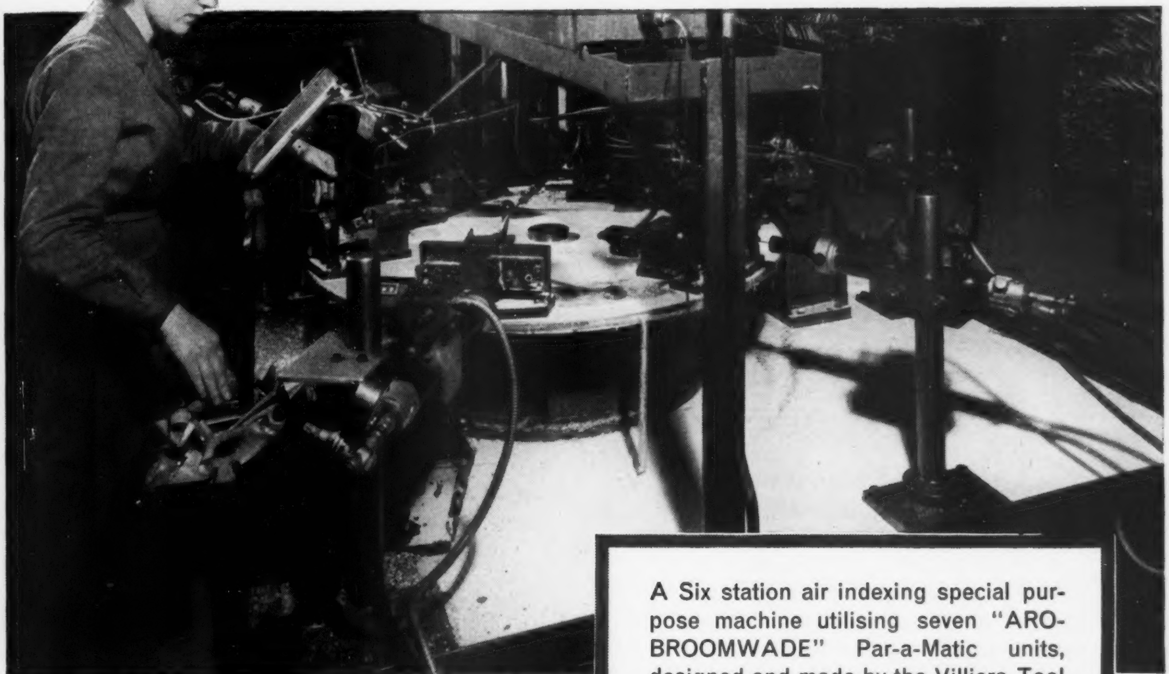
KITCHEN & WADE LTD. *Member of the Asquith Machine Tool Corporation*

ARUNDEL STREET, HALIFAX, ENGLAND *Telegrams : 'KAW, Halifax'. Telephone : Halifax 67744 (3 lines)*

K.W.398.

600% INCREASE IN PRODUCTION

...with "ARO-BROOMWADE" Par-a-Matics



A Six station air indexing special purpose machine utilising seven "ARO-BROOMWADE" Par-a-Matic units, designed and made by the Villiers Tool Developments Ltd. of Wednesfield, Staffs. for Messrs. Fry's Diecastings Ltd.

This machine carries out the following sequence of operations at a *production rate of 150 per hour. Previous methods produced only 200 per day.*

1st Station—Drill 2 holes for u.n.f. tapping.

2nd Station—Tap 2 holes 10 u.n.f.

3rd Station—Drill 2 holes for 6 BA Tapping (Multi-head).

4th Station—Tap 1 hole 6 BA.

5th Station—Tap 1 hole 6 BA.

6th Station—Unload fixture and load fresh component.

Special note should be made of the 2 spindle drilling head attached to the PAR-A-MATIC for drilling the 2 close spaced holes at Station No. 3.

Photograph by courtesy of Messrs. Fry's Diecastings Ltd.

From 200 per *day* to 150 per *hour*—this is the remarkable increase that "ARO-BROOMWADE" Par-a-Matics have effected in the production of automobile door handles for Messrs. Fry's Diecastings Ltd.

Here is but one of many examples where the speed and versatility of "ARO-BROOMWADE" Par-a-Matics makes really substantial savings and increases production.

Why not discuss your production bottlenecks with a "BROOMWADE" works-trained representative? Why not write NOW! Publication No. 443 T.E. will give you preliminary data.

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AIR COMPRESSORS & PNEUMATIC TOOLS—Your Best Investment

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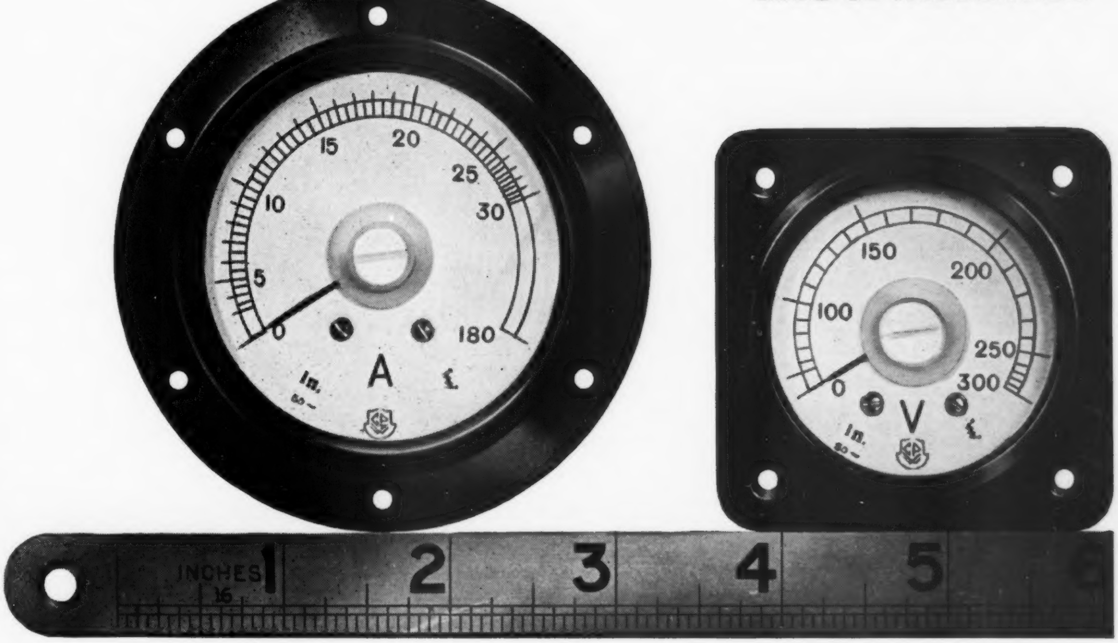
800 SAS

...and now

another 'First' for Crompton Parkinson–

Miniature Circular-Scale Moving-Iron Instruments



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humidity proof . . .
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With 2″ dial and 240° circular scale $3\frac{1}{8}$″ long, square bezel; or $2\frac{1}{2}$″ dial and 240° circular scale $4\frac{1}{4}$″ long, round bezel, in die-cast sealed metal cases. Maximum self-contained ranges: 0/30 amperes and 0/300 volts. Metal-cased, nitrogen filled and sealed; dimensions conform with Ministry of Defence Specification DEF-62. The whole range also available in moulded plastic cases.
Crompton Parkinson also make a matching range of moving coil instruments.

Crompton Parkinson
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INSTRUMENTS

–per scale inch the lowest-cost high class instruments on the market

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7 Important Reasons why

you cut costs with CROSLAND

BLANK AND PIERCE DIES

- ★ They're up to 88% **cheaper** than orthodox tools
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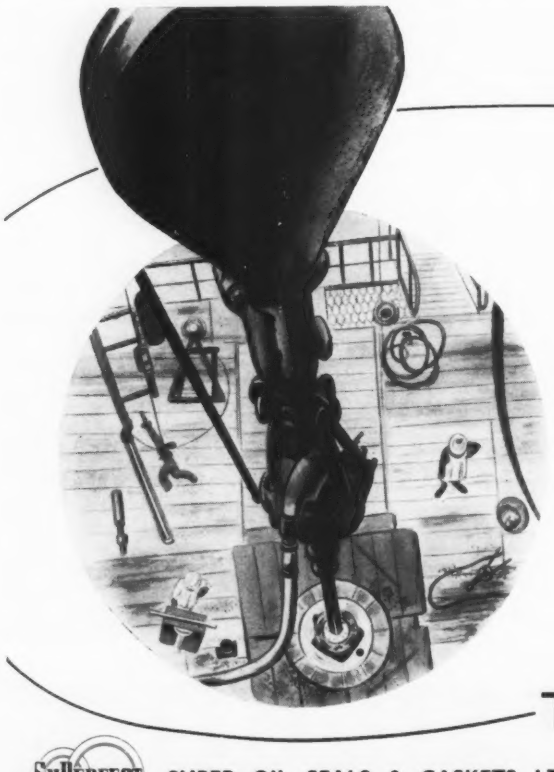
WILLIAM CROSLAND LIMITED, BREDBURY, Nr. STOCKPORT. ***Telephone : WOODLEY 2621/2***



FROM START

Oil isn't easy to find. It takes mammoth rigs and enormous drills to prise it from the ground. Its entry into the outer world is made amidst an astonishing array of derricks, pumps and pipe lines. It is treated with the reverence of gold and brings vast fortunes to those who own the land beneath which it is found.

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TO FINISH

SuPERFECT **SUPER OIL SEALS & GASKETS LTD** FACTORY CENTRE BIRMINGHAM 30

TELEPHONE KINGS NORTON 2041

INDEX TO ADVERTISEMENTS

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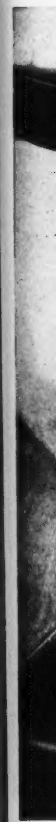

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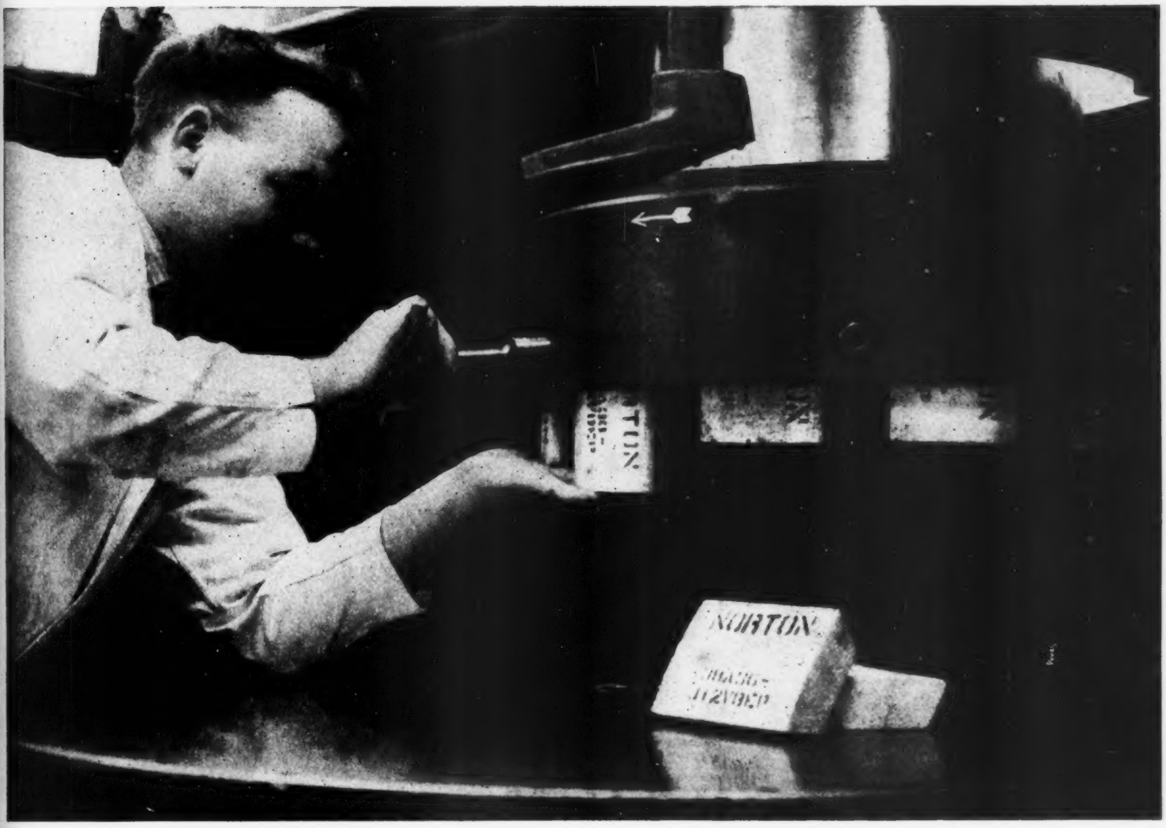
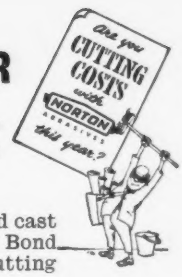


Experience shows—

NORTON SEGMENTS CUT BETTER AND LAST LONGER



The cool grinding action and natural breakdown characteristics of Norton Segments have been proved to give higher production rates and reduced grinding costs — that is the experience of users in many parts of the world.

NORTON "G" BOND—for all general purpose work on hard or soft steel and cast iron, and also for narrow contact work. A typical test report shows that Norton "G" Bond Segments with their free self-dressing action give longer life, better finish and better cutting compared with competitive segments.

No. 12 Open Structure—for use on larger areas in broad contact grinding and for work of thin section. The open structure—induced pores in the segments—ensures dissipation of heat and gives an easy free-cutting grind from start to finish.

● Norton and Alfred Herbert warehouses carry a large variety of segments in all the popular shapes and sizes. For some shapes there are over thirty different specifications available from stock. You will appreciate the advantage of this off-the-shelf delivery.

In the Norton range of wheels—over 100,000 sizes, shapes and specifications—there is one that is exactly right for your job. Let your Norton or Alfred Herbert representative help you select it; and if you require segmental type surface grinding wheels the answer will probably be Norton "G" Bond or No. 12 Open Structure.

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NGW. G.165

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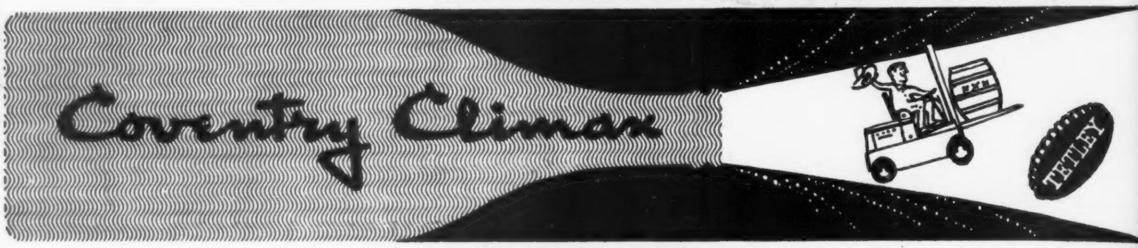

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